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MAKE DECISIONS

Developing methods to enhance
distributed design collaboration

Maria Solovjew

“It’s not hard to make decisions once you know what your values are”

-Roy. E. Disney

TITLE / MAKE DECISIONS
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ABSTRACT

Global virtual teams (GVTs), which are widely used around the world, hold a significant promise for multinational companies, due to their flexibility and innovation potential. However, they also face notable challenges caused by geographical distance and collaboration mediated by technology. The primary objective of this thesis is to document a design research process in which I develop structured means to support global virtual collaboration. In order to reach that goal, this study examines the challenges geographically distributed student teams face in the context of a global product innovation course called Mechanical Engineering 310 (ME310). ME310, originating from Stanford University, teaches students to tackle real world problems proposed by industry leading companies, by doing extensive design research, iterative prototyping, and testing with real users.

The theoretical background aims to give an overview of collaboration and communication practices of global virtual teams as well as educational activities specific to this study. Secondly, the collaborative design process and its various phases are explored; how does the teams' collaboration change in different parts of the project, what kind of challenges have been discovered, and what are the opportunities for further research.

The design research of this thesis focuses on discovering the most significant challenges ME310 teams face during their design projects as well as understanding the underlying reasons causing them. The primary research data was collected through thematic semi-structured interviews with ME310 alumni from various universities around the world. Most notable challenges were found in three areas of global virtual teamwork; tuning in, creating a shared understanding, and design tasks. Based on the analysis, one

specific design task was identified to be more critical than others; reaching consensus as a team. The findings from the design research are condensed into three design drivers which provide a starting point for concept development.

The practical part of this study focuses on developing a "Convergence Guide" that can be utilized in distributed decision-making processes. This prototype guide offers a set of methods that enable teams to create a shared understanding of knowledge, to develop teams' own evaluation criteria based on their values, and to make effective decisions as a team. To validate the proposed solution, the guide was tested with students and teaching personnel from ME310. The findings were highly encouraging and may offer new knowledge on distributed decision making processes. To conclude, although this thesis does not propose a comprehensive solution that is ready to be launched in virtual environments, the outcome can be utilized to support global distributed design collaboration in educational environments.

KEYWORDS

Global virtual teams, collaborative decision making, shared understanding, ME310, distributed design process, problem-based learning, criteria, values

FOREWORD

"The whole is greater than the sum of its parts."
– Aristotle

A team that comprises of members from various backgrounds, different disciplines as well as nationalities, indeed is greater than the capabilities of its individuals. This note may be hard to keep in mind during long multidisciplinary projects, especially when facing continuous challenges such as communication gaps, misunderstandings, and even severe arguments. Personally, I have experienced this type of project work several times. "Never again" is a phrase I remember saying to myself at the end of each project. Regardless of that, I discovered myself starting a new project only couple of months later. I cannot for certain say what prompted me to start all those projects, but after working on this thesis for several months, I must say that I sincerely miss the days of working in a team full of diverse personalities with amazing skills. Despite the challenges, I still consider my experiences of teamwork far more enjoyable than working alone.

No matter how difficult the journey has been, the challenges have been highly educating. Reflecting back on the projects I have done during my studies one thing is clear; working with great people adds tremendous contribution to any project. Multi-disciplinary teamwork is and should be considered as a great benefit and an endless source of creativity. With this thesis, I knew I decided to work on an extremely challenging topic, but I was surprised by the fact of how much I miss being a part of a team. Various backgrounds cause problems, but also bring something more valuable to the table; interesting thought patterns, imagination, varying perspectives and different point-of-views. A simple idea grows bigger and richer when someone else adds their own thoughts and twists to it. This is something I truly missed when it became evident

that solving these complex problems on my own is such a tremendous challenge.

Luckily I had an extensive support crew behind me. Aalto Design Factory is a place where one cannot be alone - there is always someone behind the corner to ask advice from or share thoughts with. The place is a an enormous source of inspiration and full of like-minded, enthusiastic people. Every day I saw students who were currently experiencing some of the problems or phases described in this study. Being able to have this touchpoint and to offer guidance increased my motivation. It also became evident that the topic truly is valuable even though I had my doubts about itevery now and then.

I would like to thank the amazing people who participated in the interviews. Each and every one of you provided valuable insights by sharing your stories and experiences. These interviews served as an essential starting point for my research. I also want to thank everyone who contributed in testing, in a way or another. This thesis benefited greatly from your valuable feedback. Moreover, I want to share my gratitude with my supervisor Anna Salmi who offered great advice throughout the project. Last, I want to thank Harri, who was always there when I needed support.

Helsinki, April 2015

Maria Solovjew

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01 INTRODUCTION

01 INTRODUCTION

1.1 GLOBAL VIRTUAL TEAMS – THE FUTURE OF COLLABORATIVE WORK?

Nowadays, global virtual teams (GVTs) are widely used around the world. Globalization, changes in organizational structures, and rapidly evolving technologies have created a need as well as an opportunity for distributed teamwork (Hinds & Mortensen 2005; Jarvenpaa & Leidner 1999; Montoya et al. 2009). Companies and organizations have realized that the use of geographically dispersed teams brings potential savings and increases efficiency. As stated by Hinds & Bailey (2003): "Distributed teams enable firms to take advantage of expertise around the globe, to continue work around the clock, and to create closer relationships with far-flung customers." (p.616). There seems to be great potential in savings as well as in innovation potential. For instance, Malhotra et al. (2001) report the story of the virtual Boeing-Rocketdyne project in which the team designed a truly disruptive part for a rocket engine, which exceeded everyone's expectations and created savings worth millions. Even though the end result was unquestionably a success, the team experienced several challenges along the way. Therefore, it is important to keep in mind that this transformation from traditional working culture to virtual worlds creates a need to address the communication challenges caused by the absence of face-to-face collaboration.

A common definition of a global virtual team (Figure 1) is a temporary working group, that is culturally diverse, geographically dispersed, and communicates mostly virtually (Jarvenpaa & Leidner 1999; Schmidt et al. 2001). There are also other similar terminologies such as virtual teams. However, they are different from global virtual teams as they are not geographically dispersed (Curseu et al. 2008). According to scholars, GVTs rarely meet in person (Curseu et al. 2008; Maznevski & Chudoba 2000). Therefore, in the context of this thesis it might also be fair to talk about hybrid global virtual teams,

which refer to groups that have occasional face-to-face interaction in addition to virtual communication (Fiol & O'Connor 2005; Griffith 2003). Hybrid structure can also suggest teams that are divided into multiple co-located sub teams. This means that subteams, that have regular face-to-face interaction, are working virtually with other subteams that are distributed geographically. Together they formulate a group that is working towards the same goal. To clarify the terminology, a common definition used in this thesis is global virtual teams or distributed teams, although the hybrid structure strongly exists in this context as well.

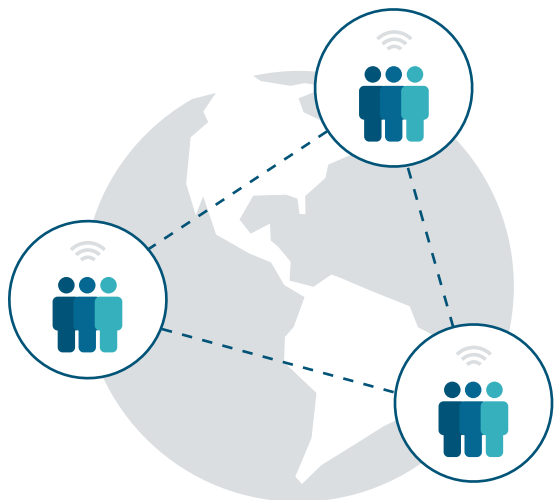


Figure 1: Global Virtual Teams in the context of this thesis

Challenges as a starting point

Global virtual teams need to rely on a wide range of information and communication technologies (ICTs) to be able to collaborate efficiently (Maznevski & Chudoba 2000; Purvanova 2014; Montoya et al. 2009). This creates challenges co-located teams do not have to experience. Regardless of that, virtual teams are often compared to traditional face-to-face teams although the structure and the working culture of these teams is "--fundamentally different from that in other types of teams, due to the use of technology" (Curseu et al. 2008 p.15). Often face-to-face work, that is full of social interaction, set standards for technology mediated communication (Montoya et al. 2009). These standards are hard to meet especially if teams are not used to collaborating remotely or do not share any history together. Consequently, virtual collaboration should have standards of its own, which should be considered in the development of new methods and technologically advanced tools.

It is critical to understand the notion of conflict in the context of distributed teamwork. Researchers agree that technology mediation affects teams dynamics and therefore, teams' ability to process information (Curseu et al. 2008). Furthermore, there are a lot of empirical studies suggesting that distributed teams experience high level of conflict (Hinds & Bailey 2003; Mortensen & Hinds 2001; Hinds & Mortensen 2005), communication challenges (Montoya-Weiss et al. 2001) and lack of trust (Jarvenpaa & Leidner 1999; Jarvenpaa et al. 2004). Moreover, unresolved conflicts often lead to performance issues (Hinds & Mortensen 2005). As stated by Malhotra et al. (2001) it is highly critical to establish a shared understanding already in the beginning of a project to be able to collaborate and communicate effectively throughout the process.

Despite the challenges, the use of global virtual teams has great advantages: low costs, flexible working practices, opportunity to utilize the best performing individuals as well as to combine different mindsets originating from different cultures and backgrounds. Suitably, Powell (2004) argues that virtual teams hold a powerful promise for organizations that use them because they enable extraordinary flexibility as well as responsiveness. Unleashing the full potential requires understanding of the challenges as well as utilizing means to facilitate effective teamwork.

1.2 FRAMING OF THE TOPIC

This thesis focuses on teams that are global, multidisciplinary, and aiming to solve complex challenges by going through a collaborative design process. Many design activities include working with physical or visual objects, such as sketching, which might be hard to do in virtual worlds (Everitt et al. 2003). Moreover, the distributed design process and its different phases have not been thoroughly studied by scholars, although research on distributed collaboration exists in other areas. Therefore, there is a need to understand collaborative design activities in distributed settings.

Moreover, the context is set in an educational environment. The starting point of this thesis is a global product development course called ME310 (Mechanical Engineering 310). ME310 is a global, design thinking-oriented course in which the students work in distributed settings comparable to modern working life. Originally created at Stanford University over 40 years ago, the course is nowadays taught in more than 15 leading

universities around the world. ME310 combines problem-based learning (PBL) and an interdisciplinary approach, immerses the students and acts as training ground to develop practical skills (Carleton & Leifer 2009). Although the distributed teamwork happens in educational environments, students work on real-life projects set by various international companies. Often, the projects are ambiguous and extremely demanding which increases pressure but also motivates the students to succeed. Moreover, the course is extremely design driven; the structure and methodologies are based on processes developed by design company IDEO and Stanford University. The student teams, although being exceptionally independent during the whole process, have extensive support from the teaching faculty. The course and its process will be introduced in detail in the beginning of section 3.

All in all, there is already research done on the effectiveness of distributed teams both global and local. But as communication and collaboration technologies continue to evolve at a fast pace, current research does not necessarily present the most updated information. Moreover, in relation to the design process, it is difficult to find concrete solutions on how to improve the collaboration or to resolve conflicts in specific design project phases. There have been attempts to create guidelines and even technologically advanced tools. Still, teams all around the world continue to struggle with similar challenges such as sharing information, cultural differences, and lack of trust. Therefore, there is a need for examining the challenges as well as developing solutions to improve the collaboration.

1.3 PERSONAL MOTIVATION

My personal motivation towards this topic arises from my personal experiences in global virtual product development teams. I have completed the course (ME310) in 2012-2013 (see Figure 2), and also have done similar multidisciplinary projects before. My ME310 experience was extremely challenging but also rewarding. Our multidisciplinary team consisted of 11 students from three different countries and five nationalities. I remember many of the problems we experienced, such as time difference, language barriers, and struggles with everyday communication. Our team also tried to address these issues during the process (see Figure 4 on page 20), but discovered that it was easier said than done. The lack of tools and methods to reduce some of

these problems was evident to me already back then. Moreover, in the academic year 2013-2014 I was part of the teaching team of ME310. During this year I had the chance to observe six student teams from a close range and experience day in, day out, the challenges they had. It became clear that during the process, the team itself is able to identify many of the problems. However, it is not an easy task to try to repair them. The teaching team faces difficult situations, as they do not have the means to facilitate the collaboration in all phases of the project, especially if there are fast-paced, unexpected challenges. During the year, it was discovered that even the most experienced professionals might not have answers to these problems. Therefore, structure and methods would be extremely helpful to aid both the teaching team as well as the students.

It is fair to say that my personal experiences of the challenges in distributed teamwork have had a tremendous impact on the motivation towards this topic. In addition, during this project I have been working for Aalto Design Factory, a passion-based learning platform, that is a part of Aalto University. Despite the fact that I had a contract of employment with Aalto, I have had the full freedom of choosing my thesis topic as well as to make progress with this project.

Figure 2: My ME310 team having a weekly hangout in 2012

1.4 OBJECTIVES AND RESEARCH QUESTIONS

The primary objective of this thesis is to document a design research process in which I develop structured means to support global virtual collaboration in the context of ME310 course. Because of the nature of this process, I have intentionally formulated the goals and research questions for my thesis to be open in the beginning, in order to allow possible solutions and concepts emerge and be defined in more detail based on interview and observation data gathered in the early stages of this project. To be able to complete this design research process, it is important to learn what are the most significant and critical challenges students face during their projects. The aim is also to discover best practices that would serve as inspiration for the design development part of this study; what kind of methods lead to successful collaboration and how to support the distributed design process.

To guide the project, three main research questions were formulated. First two questions are related to the research phase of the project. The aim is to answer these questions through a literature review and design research, which includes in-depth interviews with alumni of the ME310 course. The second part includes a guiding question, which this thesis aims to answer in the production phase of the project. The goal is to create a concept solution based on needs discovered in the research phase. In the end, the aim is to validate the concept-level solution by testing it with student teams. The learning outcomes of this thesis can be utilized in the development of the course (ME310) and possibly other courses with similar course profiles.

Research phase

1. What are the most critical challenges multidisciplinary global virtual teams encounter in their collaboration, during an intensive product development project?

2. What are the underlying reasons causing these challenges?

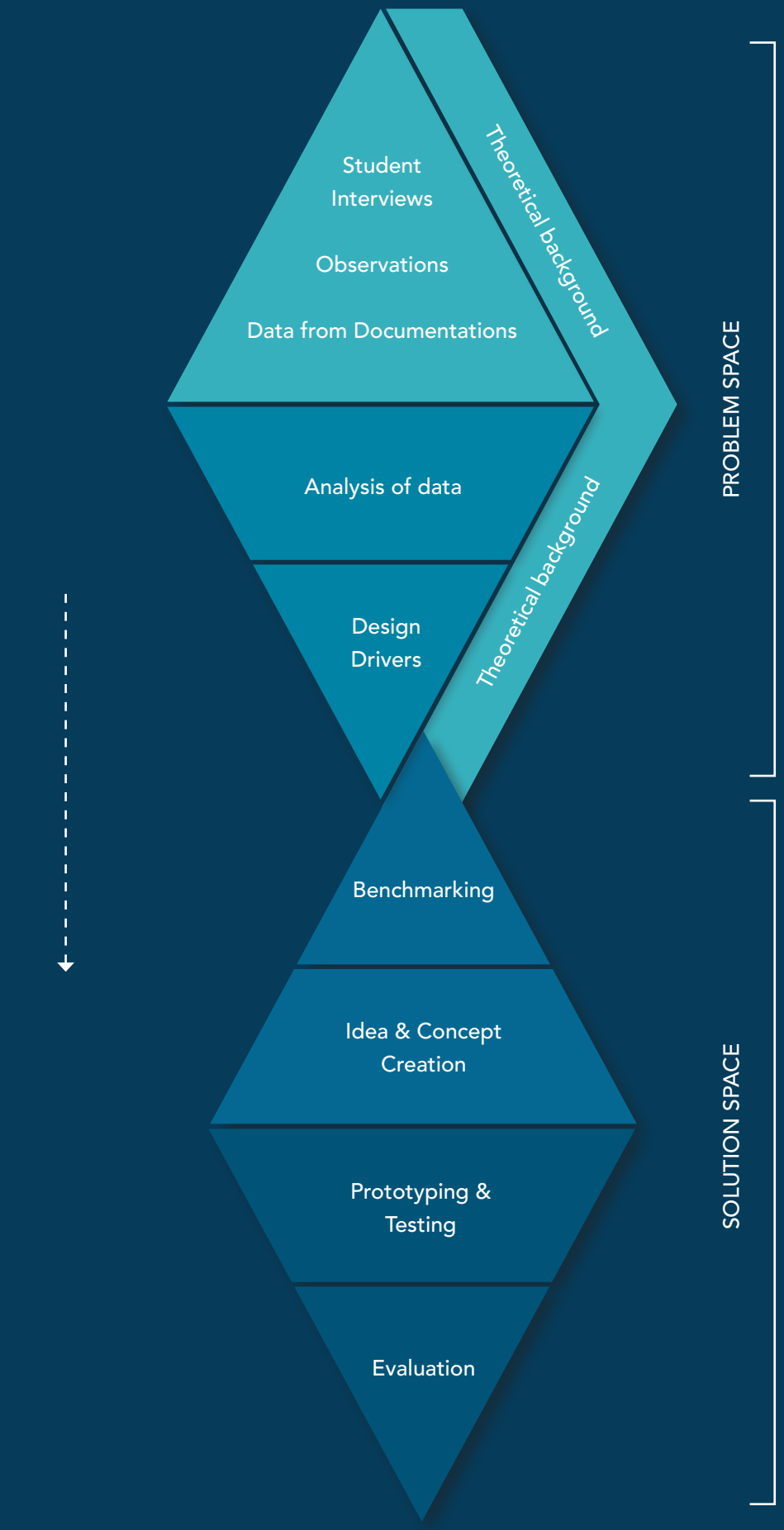
Design development phase

3. How to improve the global distributed design process with the development of structured means?

1.5 STRUCTURE OF THESIS

The structure of this thesis (Figure 3) roughly follows the Design Council's (2015a) divergence and convergence process. In the beginning, the research scope became large due to the complexity of the problem space. Condensing the focus to be suitable for a Master's thesis was challenging due to the amount of global virtual team challenges discovered. Furthermore, most of the problems were complex in nature and therefore difficult to solve. After careful analysis of data and choosing a specific direction, the topic became more condensed and easier to grasp. In the end, the focus was set on creating a shared understanding in a specific phase of the design process; convergence, as communication of knowledge in this particular phase as well as making decisions as a team were proven to be critical tasks in which supportive means were needed.

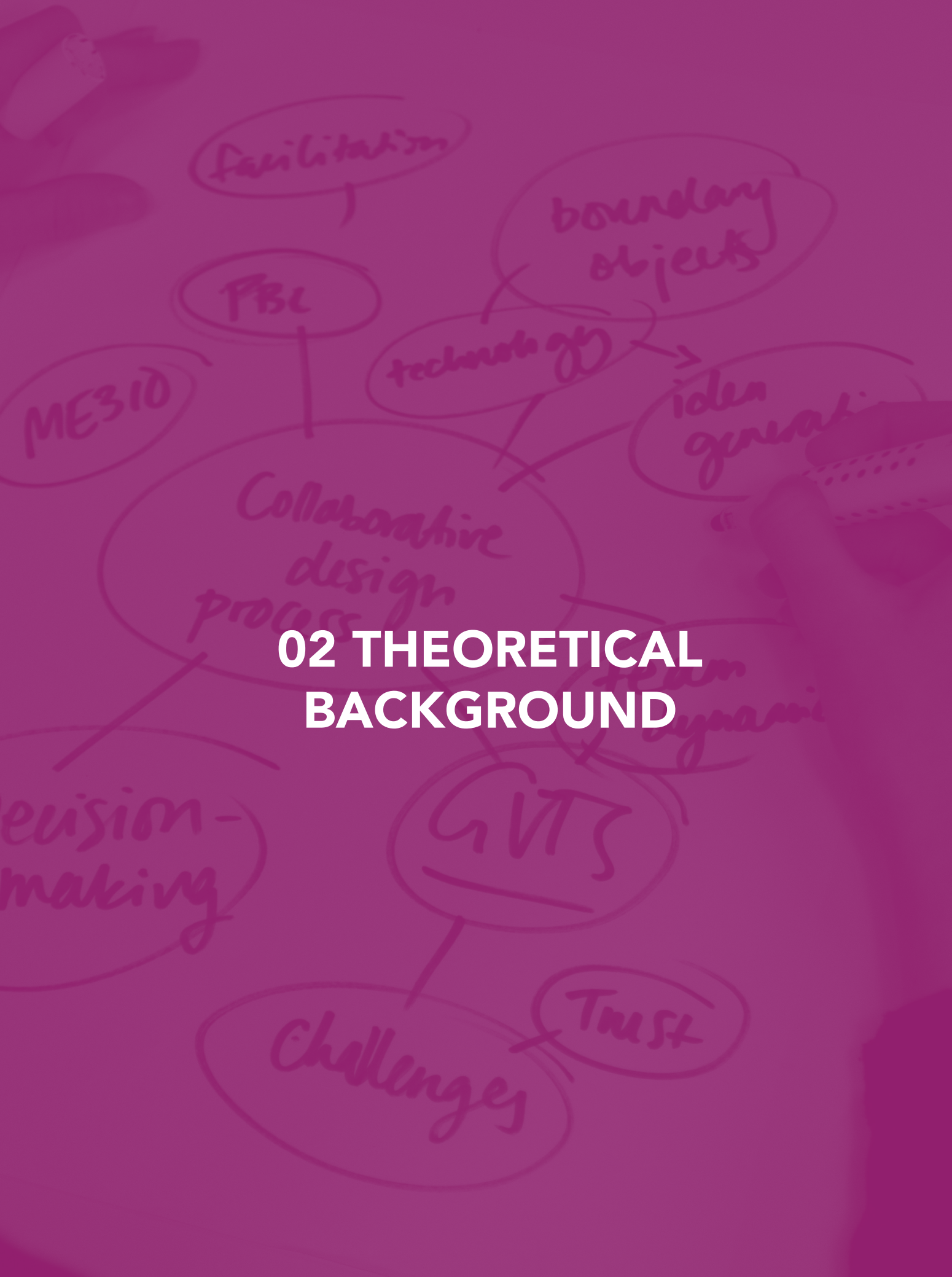
The structure of the written part is divided into five main sections: introduction, theoretical background, design research, concept development, and discussion. After this introduction, the second part presents a theoretical background, which aims to cover important aspects of distributed teamwork and collaborative design processes. In parallel to the literature review, design research was conducted (section 3). This part explains the research context, methodologies used, and overall findings from the research. After discovering needs and requirements; the design development (section 4) part begins by benchmarking existing solutions and frameworks. Furthermore, this section covers all the design phases from initial brainstorming to prototyping and testing with target users. The final part consists of evaluation and discussions on next steps.



▲ ***Figure 3: Structure of thesis***

Figure 4 - Signs used as visual cues during team meetings to overcome language barriers

Figure 5 - Students working remotely via Skype



02 THEORETICAL BACKGROUND

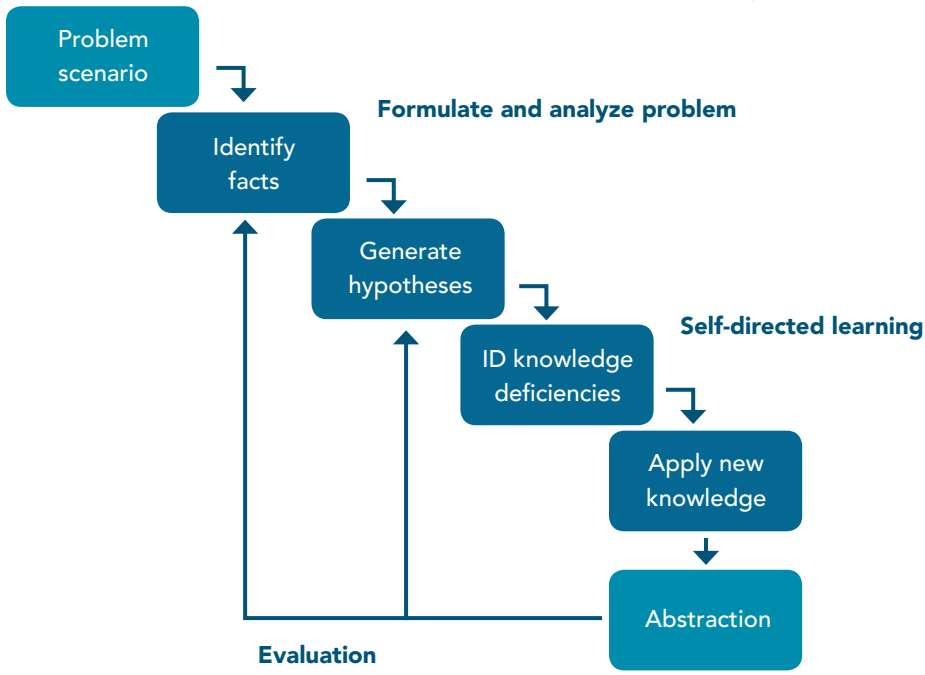
02 THEORETICAL BACKGROUND

The aim of this literature review is to give an overview of collaboration and communication practices of global virtual teams. The focus is also on the design process and its various phases; how does the teams' collaboration change in different parts of the project, what kind of challenges have been discovered, and what are the opportunities for further research. Rahman et al. (2013) state that distributed design process and its various phases have not been fully investigated in design research. Therefore, finding adequate literature for this thesis was a difficult task. Further description of the context for this study will be provided in the beginning of section 3.

2.1 PROBLEM-BASED LEARNING

As this thesis focuses on global virtual teams in educational environments, there is a need to understand educational activities specific to the context. Problem-based learning (PBL), although not focused specifically on virtual teamwork, is one of the learning approaches that emphasize practical, collaborative experience in learning, concentrating on real-world problems (Hmelo-Silver 2004; Carleton & Leifer 2009). PBL is based on facilitated self-directed learning (SDL) that encourages student teams to explore the problem space, discover needs by experimenting and developing strategies towards potential solutions (Hmelo-Silver 2004). Moreover, reflecting on knowledge that is gained, students go through an iterative learning cycle (Hmelo-Silver 2004), which is described in Figure 6. Students are given freedom to make their own deductions to define problems they need to study further, and to develop potential solutions. Teachers mainly guide students through the learning process, acting as facilitators or coaches (Carleton & Leifer 2009; Hmelo-Silver 2004). This means that teachers provide guidance and mentoring starting from handing out instructions and

Figure 6: Problem based learning cycle (Hmelo-Silver 2004 p.237)



methods to facilitating workshops (Hyppönen & Lindén 2009 pp.50-51). Moreover, the teacher's role is not to provide any ready-made answers for problems, as students need to define and discover the solutions on their own.

2.1.1 Goals of PBL

Interdisciplinary teams are common in problem-based learning; students from various backgrounds usually work in small groups to take advantage of group members' diverse skills and expertise. Main goals of PBL are to ensure that students gain effective problem-solving skills and are able to construct an extensive knowledge base, to become skillful collaborators (Hmelo-Silver 2004). The main objectives include acquisition and extension of new knowledge and expertise as well as learning problem-solving skills (Perrenet 2000). PBL also aims to ensure that students gain life-long skills, such as analyzing and experimenting, which can be transferred to other problem-solving tasks later on. One essential advantage of PBL approach is that often it increases students' levels of motivation and interaction (Carleton & Leifer 2009). Achievable and tangible problems assure the autonomous learning process that enables student teams take charge of their project, to set targets and plan their actions to achieve concrete results. The setting of personal or team specific goals, coming up with a strategy for executing tasks to reach the chosen aims, and reflecting on the process, are all important aspects

of this type of project work (Perrenet 2000). Nonetheless, the overall aim of the project is not directly the outcome itself, but learning from the whole process (Hyppönen & Lindén 2009).

2.1.2 Facilitated learning in PBL

Facilitator's role is an important part of PBL; students are extremely self-directed but also in need of guidance and team interventions every now and then. Objective facilitation is needed to moderate teams' processes without interfering with the content. The teacher may not be an expert in the area of the project, but knows the learning process and therefore, is able to guide students through the project (Hmelo-Silver 2004). Wardale (2013) describes group facilitation as a process where a person outside the team can objectively assist the group in problem solving or decision-making processes to foster group's effectiveness. Facilitator needs to be able to adapt and recognize when to interfere, which requires experience. Especially when dealing with complex problems and high levels of uncertainty regarding the project direction, an experienced facilitator can be of great help to keep the team on track. In fact, an important part of a facilitator's role is to be able to design and prepare an intervention if needed (Kolfschoten et al. 2007). As stated by Kolfschoten et al. (2007) careful preparation is one the most critical tasks and includes detailed planning as well as choosing the right methods and tools for the specific purpose of facilitation. Evaluation and monitoring after the session is also needed to ensure continuity.

2.1.3 The meaning of ill-defined problems in PBL

In PBL the projects are focusing on real-world problems, which can be highly complicated. Often industry partners or the teaching team define the project briefs. 'Ill-defined' problems (also known as wicked problems) that are a common starting point in PBL, have no definite formulation; problem context is vague, goals and criteria might be unknown in the beginning, but through construction and reflection the solution space becomes more and more narrow (Du et al. 2012). Wicked problems were first introduced by Horst Rittel in 1960s (Buchanan 1992). Rittel's original description, cited by Buchanan, defines wicked problems as "-- a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decisions makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing." (Buchanan 1992 p.15). Buchanan (1992) points out an important issue arising from this statement: the indeterminacy, which refers to the

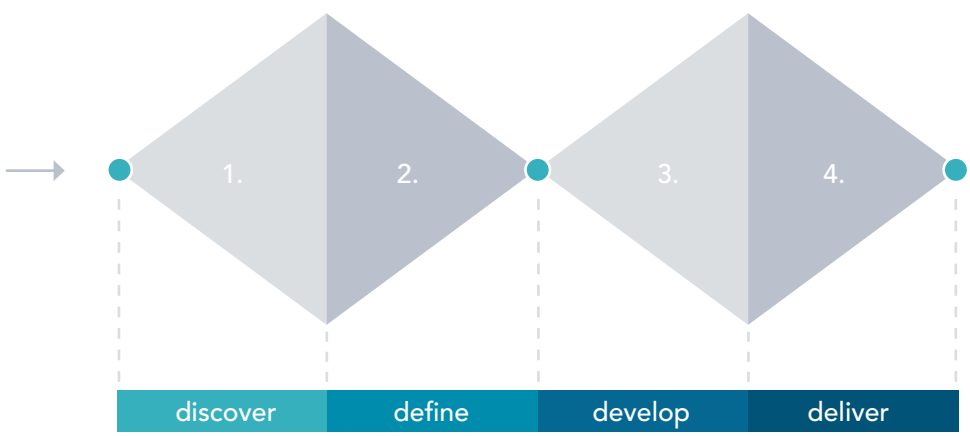
fact that there are no restrictions nor requirements regarding the solutions proposed to wicked problems. Moreover, the solutions are never right or wrong, only good or bad, and there are always several possible answers.

2.1.4 PBL Process

The level of ambiguity is high in projects that start from such complex settings. To reach a successful solution, teams need to go through several attempts and iterations and most likely fail a couple of times in trying. "In order to cope with ill-defined problems, designers have to learn to have the self-confidence to define, redefine, and change the problem-as-given in the light of the solution that emerges from their minds and hands" (Cross 2006, p.24). This means that students need to be able to deeply explore the problem space by researching the topic, interview and observe users to discover needs, to test out assumptions, and to redefine the scope of the project according to their findings. Often this process is highly engaging and students constantly learn while doing.

Similarly, the Design Council's "Double Diamond" model (Figure 7) describes this process of diverging and converging (Design Council 2015a). First, designers go through the discovery phase in which they explore the problem space by engaging with potential users to discover needs and opportunities. The next phase acts as a filter in which the discoveries are analyzed and evaluated to narrow down the scope. In the development phase the team diverges again to create concepts to find tangible solutions to

Figure 7: The Double Diamond-process model (Adapted from Design Council 2015a)



the discovered problems. After testing and evaluation, final decisions are made to guide and start the implementation phase. Although this process model fits to the context of this thesis, the reality may not be as linear as described above, as students usually go through all these phases several times.

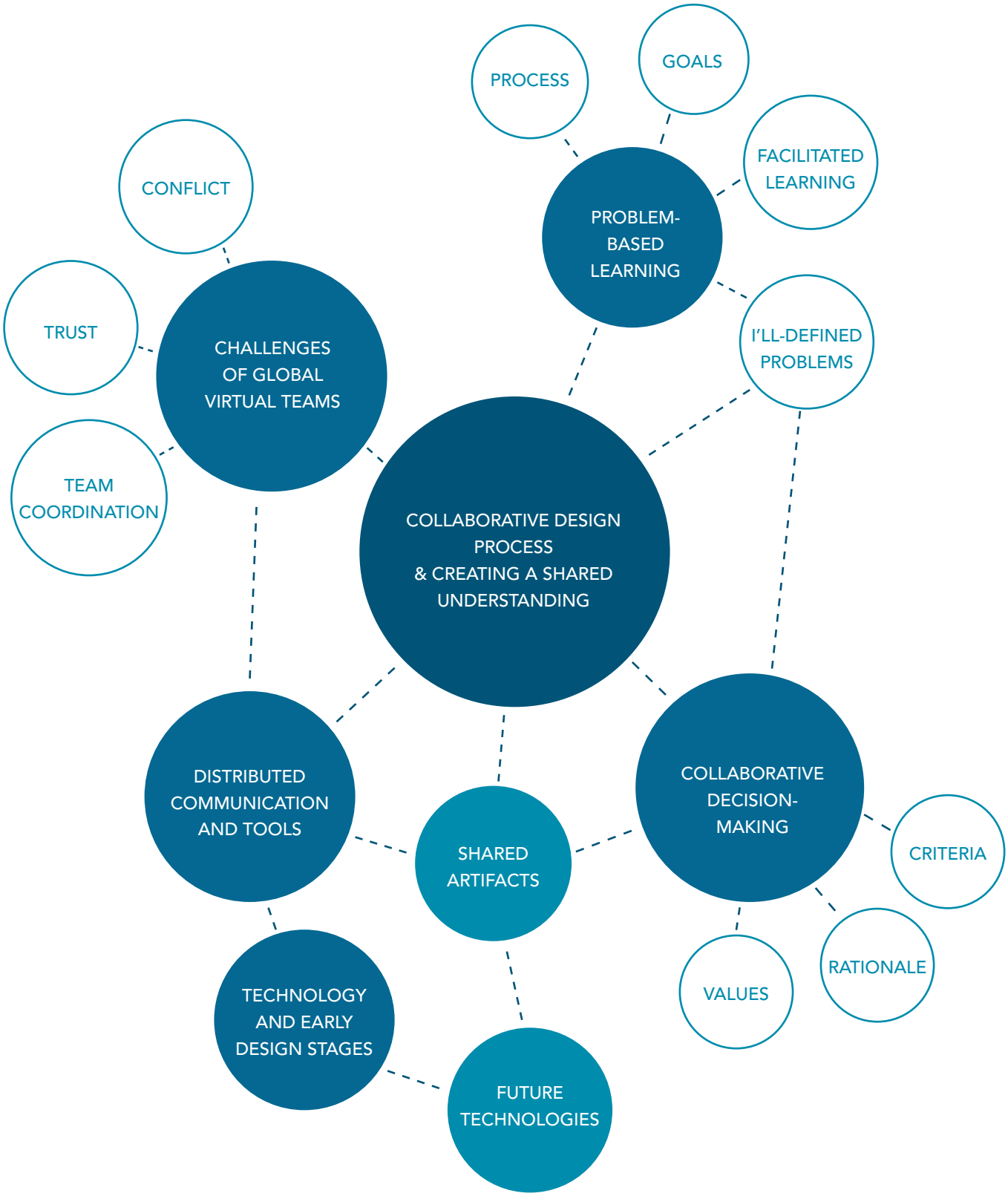
2.2 CHALLENGES OF GLOBAL VIRTUAL TEAMS

To be able to understand challenges of GVTs it is important to look at team dynamics and communication. According to research, global virtual teams frequently suffer from high level of conflicts (Hinds & Bailey 2003; Hinds & Mortensen 2005; Purvanova 2014; Mortensen & Hinds 2001). Most cases show that different teams face similar challenges, "--such as difficulty communicating and coordinating activities, misunderstandings, feelings of isolation, and poor team leadership."(Purvanova 2014 p.4). Often, GVTs consist of people who are not familiar with each other when the project starts, they might not ever meet in person and therefore, the distance might prevent team members to build strong relationships. "Feelings of not being there with one's communication partners stand to prevent distributed team members from sharing relational information that help teams to develop trust" (Hinds & Bailey 2003 p.620). Researchers also claim that the use of technology in communication reduces unplanned social events, visual as well as contextual cues, and information transfer, which affects the group's awareness of processes and progress (Hinds & Bailey 2003).

2.2.1 Role of conflict

Hinds & Bailey (2003) argue that conflicts in global virtual teams happen mainly because of two reasons: "the distance that separates team members and their reliance on technology to communicate and work with one another" (p. 615). However, based on research there are no clear evidence or guidelines on how teams might be able to reduce or solve conflicts. There is also a strong relationship between conflict and teams' performance, especially in complex tasks (Hinds & Bailey 2003; Hinds & Mortensen 2005). Conflict can decrease teams' motivation and commitment, which might interfere with the group's performance. The impact conflict has on the teams' success and collaboration may depend on the type of conflict. Task conflict refers to disagreements with work content, affective conflict (also known as emotional or interpersonal) is related to highly emotional arguments, and process conflict affects teams' approach to the

Figure 8: A mindmap of different themes discussed in theoretical background



task and processes at hand (Hinds & Bailey 2003). Studies done by Hinds & Mortensen (2005) imply that especially task conflict is associated with lower performance.

Hinds & Bailey (2003) report of studies stating that conflicts in global distributed teams are easier to neglect compared to co-located teams. Due to distance, it might take longer to realize a problem exists and therefore, the damage may be harder to repair. Also, distance affects the immediacy of sharing, and sometimes, information might get lost accidentally. All information is not easily shared via technology, although tools are advancing rapidly. Moreover, especially contextual information may be hard to transfer, and therefore team members might have to work on the basis of unequal information with varying perspectives, which leads to misunderstandings (Hinds & Bailey 2003). Resolving conflict is hardly as effective as in co-located settings. However, Hinds & Mortensen (2005) argue that teams may be able to reduce conflict by having more spontaneous and casual conversations. Spontaneity in collaboration may also foster stronger creation of a shared understanding and team identity, which seems to be critical for successful collaboration in distributed teams. More discussion on this topic will be presented in following chapters.

2.2.2 Importance of trust on team dynamics

As global virtual teams have to deal with uncertainty, the importance of building trust early is essential (Jarvenpaa & Leidner 1999). “Product development requires close cooperation between team members; this in turn requires trust” (Tavčar et al. 2005 p.560). The need for trust is even more critical in virtual environments. But, trust may be challenging to develop when face-to-face time is limited or non-existent, team members do not share any history together, or have to rely on technology in communication,. Moreover, low levels of contextual information, which is common in distributed teamwork, has a negative impact on trust building in technology mediated human relationships (Jarvenpaa et al. 2004). “No matter which theoretical perspective one takes, the anticipated effect of technology mediation on group conflict appears to be negative” (Hinds & Bailey 2003 p.620). For that reason, teams should actively try to build trust in the beginning of the project. As Jarvenpaa et al. (2004) discovered, “trust provides important benefits for IT-enabled relationships” (p.262), such as positive moderating effects on team cohesiveness and communication. This is especially important for teams with weak structure or high uncertainty, although the impacts are highly situation specific. In addition, the direct effects on task performance are yet to

be discovered (Jarvenpaa et al. 2004).

Naturally, backgrounds and characteristics of team members' influence trust building in teams. Jarvenpaa & Leidner (1999) argue that social communication, being enthusiastic, and taking initiative helps a team to create a trustworthy atmosphere in the beginning. Previous positive experiences of teamwork, and knowing other team members' skills and backgrounds serve as an advantage (Tavčar et al. 2005). Moreover, high initial trust may help teams to maintain a good working culture. In the studies conducted by Jarvenpaa & Leidner (1999) it was noticed that teams that possessed high initial trust were able to maintain it by being predictable in their communication, having clear roles and being unbothered by task failures. In contrast, lack of task focus, social interaction and excitement can prevent the team to develop high levels of trust during the project. It seems to be easier to set a good working culture in the beginning than to change it later on. However, as Jarvenpaa & Leidner (1999) suggest, trust is also sensitive. Although teams may be able to develop trust, it might be temporary and vulnerable to changes.

2.2.3 Team coordination and effective kick-start

"A large advantage in composing an effective project team is knowing the team members and their skills and knowledge" (Tavčar et al. 2005 p.566). But what if team members are completely unknown to each other beforehand? Common backgrounds and familiarity have a positive impact on team's readiness to collaborate together, which affects the whole design process (Tang et al. 2011). However, global virtual teams often do not share history together, they come from various disciplines, and therefore, team members need to take more effort in the beginning to establish a common understanding of the teams' abilities and resources. Moreover, establishing clear team processes, expectations and team members' roles in the beginning of the project is crucial (Lyons et al. 2009). This should include protocols for team specific collaboration that are set in the beginning together with all team members. Knowing who does what, and how to separate and integrate different tasks is also beneficial. Communication standards should be established to enable effective collaboration (Montoya et al. 2009). Furthermore, defining clear roles also fosters sharing of knowledge (Curseu et al. 2008). "Goal-directed behavior and a sense of self-efficacy increase people's willingness to work towards the goal (Hinds & Weisband 2003 p.22). Usually, team leaders take charge of delegating tasks and roles. However, the dynamic of the team is different

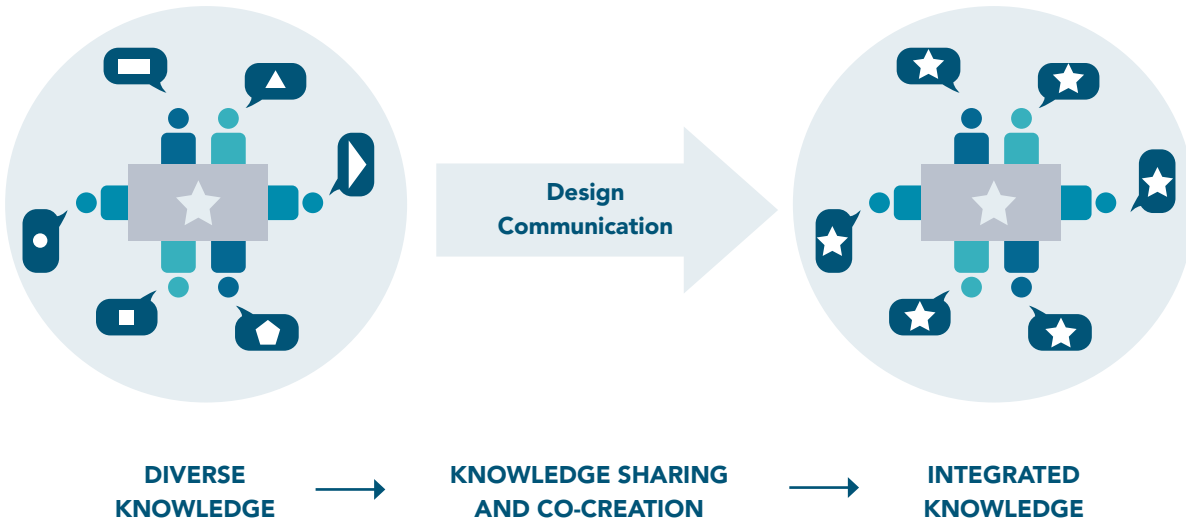
when there are no leaders as all team members are equal. Curseu et al. (2008) state that role ambiguity happens more easily if there are no leaders. Defining clear roles and tasks reduces uncertainty, but it might be challenging to accomplish in teams that have no predetermined leaders or responsibilities. This is an important note that should be kept in mind in ambiguous projects that are also full of diversity.

2.3 COLLABORATIVE DESIGN PROCESS AND CREATING A SHARED UNDERSTANDING

Collaborative design is a process in which designers from different disciplines share and integrate their knowledge of both the design process and the project content (Du et al. 2012; Kleinsmann 2007; Lahti et al. 2004; Rahman et al. 2013). The goal is to combine expertise, diverse ideas, and knowledge, to create a shared understanding of teams' process to formulate common goals (see Figure 9). Moreover, a shared understanding, is "a collective way of organizing relevant knowledge" (Hinds & Weisband 2003 p.21), which has a significant impact on team's performance and the ability to collaborate together. Considering multidisciplinary teams, in which members come from various backgrounds and disciplines, the process of reaching a shared understanding may be more than challenging. Due to geographical distance in GVTs, the process becomes harder; understanding others' perspectives remotely is never an easy task. Moreover, sharing knowledge to create a mutual understanding of the design content is demanding. Knowledge sharing in this context simply refers to information that is supposed to have a single meaning for both the sender and the recipient (Bechky 2003 p.). In contrast, knowledge may actually have different meanings depending on the context, which causes a problem of not knowing what has been transferred (Bechky 2003). Valuable information for one person may not be as significant for the other or knowledge may have different meaning. This note should be acknowledged especially in the context of distributed teamwork in which it is critical to formulate a common understanding of relevant knowledge.

As mentioned earlier, it is common that GVTs suffer from high level of conflict. A mutual understanding enables distributed teams to collaborate together more effectively and may prevent conflict. Hinds & Weisband (2003 pp.22-23) present multiple

Figure 9: The collaborative design process (Kleinsmann 2007 p.61)



ways of how a shared understanding can contribute to teams' performance. First, it enables team members to predict others' behavior, which influences positively on independence, reducing the need for constant monitoring of others. Moreover, it enables more efficient use of resources and decreases problems with implementation. The ability to rely on others, understanding of teams' processes will have direct effects on motivation of team members. All in all, if the team is able to reach this type of shared understanding, it will reduce conflict and frustration. Therefore, the pursuit of shared understanding should be encouraged and emphasized early.

2.3.1 Factors influencing the creation of a shared understanding

According to Kleinsmann (2007) a shared understanding will be created if team members have similar perceptions about the design content and also, different actors' knowledge bases. The ability to learn as a team, to relate to one another, and to develop mutual goals as well as expectations is critical in this process (Hinds & Weisband 2003). Some studies further emphasize the importance of social connectedness and knowing the people you are working with (Larsson 2007). In multidisciplinary global virtual teams the process of creating a shared understanding is significantly more complicated. Combining different backgrounds and disciplines as well as the distance that separates the team members from each other makes it difficult to reach a common point-of view (Everitt et al. 2003). Therefore, getting to know other team members,

their backgrounds, and understanding how they think, fosters the creation of a shared understanding on the process level. As mentioned earlier, trust is a key element in enabling this. Furthermore, knowing who knows what and who to trust is essential (Larsson 2007). On the content level, visual representations, such as sketches and objects, play an important role in the process (Rahman et al. 2013). Shared objects, which will be discussed further in chapter 2.4.1, have proven to work well in similar work contexts, but the results in cross-occupational work are not as positive (Bechky 2003). For example, when an engineer shows a sketch to a designer, the interpretation may differ from the original meaning. Still, concrete, tangible means are needed as verbal descriptions are not enough to transfer the knowledge (Bechky 2003).

The ability to create a common point-of-view is a result of multiple components. Kleinsmann (2007) discovered several factors influencing the creation of a shared understanding in multidisciplinary teams in industry, which can be divided into three levels: actor, project, and company level. One of the main findings was that transformation of knowledge between people from different disciplines should be taken into account (Kleinsmann 2007). The language used by designers may translate into a different meaning by members from other disciplines, and past experiences also influence this transformation. The way we see and the way we communicate about it may differ as verbal interaction is often fuzzy and shaped by background and experiences (Rahman et al. 2013). On the second level, ability to process information was identified to be an influencing factor (Kleinsmann 2007). Information might not be properly processed or shared, documents may arrive late and status of processing of the documents might be unknown. Overall, it is hard to keep track on everything especially if others' work habits are unknown. On the company level, organization of resources and task division was noted as a critical factor (Kleinsmann 2007). Although the study done by Kleinsmann (2007) focused on professional co-located teams, the results should be comparable to remote collaboration, as all the factors influencing the creation of mutual understanding exist in distributed team work as well.

If co-located collaborative design teams face such challenges in creating a shared understanding, global virtual teams might struggle with it even more as technology confuses the collaboration. Some researchers argue that informal and spontaneous communication may help in the development of shared understanding as well as team identity, which reduce conflict and moderate the teams' relationship (Hinds &

Mortensen 2005). Clearly, social interaction and trust are crucial factors for building shared understanding since it affects team members motivation and willingness to share knowledge as well as contextual information (Larsson 2007). Motivation should be kept in mind, as hypothetically speaking, an enthusiastic and united team will most likely produce a better outcome as well as more satisfactory working culture. Similar backgrounds and previous experiences contribute positively to mutual understanding (Hinds & Weisband 2003). However, often GVTs do not share any history together, and therefore, reaching the state of being able to have spontaneous talks and trust might require time and extreme effort. Therefore, an interesting question is: how to enable the creation of a shared understanding early on in the project?

2.3.2 Shared Design Thinking Process Model (S-DTPM) – Means of formulating a common understanding

There are researchers who have been focusing on means that enable the creation of mutual understanding. Du et al. (2012) developed a Shared Design Thinking Process Model (S-DTPM), which provides means to discuss and to formulate a common understanding while performing design tasks. The aim is to provide support for collaborative design teams' process already during the task, as often teams are not able to perform these activities before completion of the task. The researchers discovered that a shared understanding of the process as well as the content is critical for the success of the team. Furthermore, without mutual understanding critical information for example for design decisions and the reasoning for them might get lost.

Du et al. (2012) present four types of process elements occurring in collaborative design when a team is trying to reach a common direction: "argument, evolution, association, and fusion" (p.114). These steps are related to creating a shared perspective in different phases of the project, which means a state where all team members agree on a common goal. Design teams rarely establish a shared perspective quickly and effortlessly, as individuals have their own opinions and varying knowledge bases. As discovered by the researchers, argument occurs when design team attempts to create shared perspective by persuading other team members to share their point of view by giving out clear reasoning. Evolution happens when individuals attempt to redefine the commonly created perspective by presenting new opinions. Evolution continues until the perspective is stable and none of the members have the need to modify it. Moreover, association describes the transformation phase from an individual's perspective to

another team member's perspective. Last, fusion explains the situation when individual's similar perspectives can be merged into a single coherent vision. Often teams need to go through several attempts and iterations to reach a common point-of-view. It hardly happens naturally especially in distributed settings.

Based on the S-DTPM framework, the researchers developed a prototype of a software tool, called "TeamMind", to capture design intents by using visual graphs (Du et al. 2012). The aim of the tool was to enable designers to reach an understanding of the design task and problem as well as recording the progress in a visual way. The objectives and the process model behind this solution seem to be promising but further development is required to realize the potential.

2.4 DISTRIBUTED COMMUNICATION AND SHARED ARTIFACTS

Communication is one the most critical tasks for GVTs to perform effectively throughout the different phases of the project. Today, teams have a wide range of technologies at their disposal that serve different purposes, but the requirements of distributed design work have not been fully identified (Rahman et al. 2013). As GVTs are more and more common, the need to facilitate and guide the communication becomes increasingly important (Montoya et al. 2009). Choosing the right tools for different tasks or steps is important. Some tools also require training, which might create a higher threshold for starting to actively use them. Moreover, project management or team coordination tools are different from design process tools; teams need to exploit a wide range of tools for different tasks to collaborate effectively (Montoya et al. 2009). Montoya et al. (2009) divide team functions into four different categories: conveyance, convergence, project management, and social/relational (p.140). Some functions, such as complex problem solving tasks, require more interaction and real-time communication, as for example project updates and sharing of documents can be done via email. Montoya et al. (2009) also point out that so far researchers have been focusing more on social communication than task specific collaboration with information technologies.

Communication tools can be divided into two categories: synchronous and asynchronous tools; synchronicity refers to real-time communication that engages all team

members simultaneously, such as video conferencing, and asynchronous means refers to tools such as e-mail and document repositories (Curseu et al. 2008; Montoya et al. 2009). Especially synchronicity is important for GVTs (Curseu et al. 2008), as it improves the immediacy of feedback and increases interaction (Rahman et al. 2013). Moreover, synchronicity is beneficial especially in the convergence phase as well as in social tasks (Montoya et al. 2009). Social interaction and being able to see other team members brings teams closer to face-to-face settings. However, Rahman et al. (2013) claim that even that may not be enough in distributed collaborative design projects. Overall, both means are necessary for global virtual teams to collaborate efficiently. As mentioned above, different tasks and various phases of the projects set different requirements for the technologies used. For example asynchronous tools, such as document repositories that are designed for sharing project-related documents (Montoya et al. 2009) assist teams to convey and preserve the knowledge that is created during the project. All in all, a balanced mixture of both means, as well as clear standards on how to use the tools and for which purpose, are needed.

Shared artifacts enabling effective collaboration

Designers are used to working with physical objects and visualizations. Rahman et al. (2013) studied the important role of visual externalizations, shared artifacts, in collaborative design projects and its various phases. Similarly, Lahti et al. (2004) emphasized the importance of working with shared visual representations. A shared artifact acts as a boundary object in design collaboration formulating a bridge of understanding between different participants. Traditionally, boundary objects can be described as shared objects, which allow different interpretations (Brandt 2006). The notion of a boundary object is widely used in design and cross-disciplinary studies. However, not all objects can be considered as boundary objects. Nicolini et al. (2012) present a novel framework, which enables deeper understanding on the role of objects in cross-disciplinary collaboration. In this framework, objects are categorized as boundary, epistemic, infrastructure related, and collective objects of activities. Each approach offers different perspectives on how these objects are being used in collaboration and what kind of roles do they posses, although all categories include commonalities as well. Moreover, an object can change status during a project, transforming its meaning during the collaboration.

Going back to the traditional approach, even though objects can be interpreted dif-

ferently depending on the context and location, they remain to have their immutable identity. Therefore, these objects serve as a link between different locations; a shared visual context helps teams to setup a common point-of-view and build stronger relationships in collaborative design projects. This seems to be especially important when working in different locations. On the other hand, objects can also cause misconceptions if the meaning and interpretation of it behind it is not clear (Nicolini et al. 2012). The researchers further categorize objects as being primary and secondary. If a secondary object, in which most boundary objects would fall into, mainly explains the "how" in collaboration, the primary object explains both "why and how" (Nicolini et al. 2012). The why is important in terms of being able to see what motivates the collaboration to begin with.

Rahman et al. (2013) explain that the use and manipulation of artifacts becomes increasingly complicated in geographically distributed design teams; in addition to all communication, also physical and visual objects are displayed indirectly. In research, improving the accessibility to visual design objects is seen as an important help for distributed design teams. The gap should be reduced to form more close-knit teams. Hence, this could be a potential direction to be studied further. Rahman et al. (2013) compared asynchronous and synchronous communication settings in various stages of design collaboration and results seem to imply that modifying a shared artifact in a synchronous setting is seen as more efficient and fluent, especially in phases which requires synchronous communication while modifying an artifact collaboratively. The results suggest that the use of shared artifacts is especially important in the convergence phase when it is critical to posses a shared understanding. Objects and visualizations provide further contextual information that cannot be conveyed verbally. The importance of a shared workspace is also significant. A shared view is not adequate, there needs to be a possibility to perform shared activities (Rahman et al. 2013). This refers to means of simultaneously modifying objects from different locations. Some shared objects also become a part of the infrastructure (Nicolini et al. 2012). All in all, the factors mentioned above set some requirements for workspaces both in digital and physical locations. Shared activities also increase the level of concentration; it is easier to maintain focus on discussion with physical objects to discuss about (Everitt et al. 2003). Lahti et al. (2004) also state that there is a need for proper social infrastructure when working with shared artifacts. Social features such as continuous audio or chat support the interaction and creation of shared objects in virtual environments.

2.5 TECHNOLOGY AND IDEA GENERATION

Early project stages, such as idea generation and conceptual design, are one of the most critical phases in product development and design processes (Ganser et al. 2007; Tang et al. 2011). Moreover, Ganser et al (2007) state that creative methods, such as brainstorming and mind-mapping are not sufficiently supported in online environments. Many of the CAD tools are more suitable for detailed designing (Robertson & Radcliffe 2009), but not for intuitive and quick idea generation. In distributed collaboration, creativity may be damaged due to delays, technological problems, and lack of spontaneity. Digital worlds cannot always match the speed and low threshold required for effective sharing of ideas; tools may be hard to use or require learning. Also, transferring knowledge into a digital format takes time. In the creative process, ideas are usually created impulsively (Ganser et al. 2007), and therefore, delays and small obstacles caused by technology might be harmful for the creative process. Gül & Maher (2009) compared face-to-face sketching to virtual 3D designing and discovered that each step or action took more time to complete when designing virtually in remote locations. However, the choice of media and tools matter as well. It might even be that these problems mentioned above do not exist as tools and technology continue to evolve. For example, Tang et al. (2011) did not find significant differences in their study, when both traditional and virtual settings for conceptual design were similar.

Rahman et al. (2013) researched the differences between asynchronous and synchronous communication setups in collaborative design processes and discovered that geographical distance has negative effects especially on idea generation phases. However, the results imply that a synchronous communication channel was seen as more beneficial over asynchronous in this particular phase. Contradictory, Girotra et al. (2010) suggest that asynchronous idea generation might be done effectively. In their study, interactive brainstorming as well as the act of building on top of others' ideas, was not proven to be more successful than individual idea generation, when measuring the quality of the best ideas generated. Therefore, this study suggests that asynchronous idea generation might be as effective as well as the activities done in real-time settings. However, this study is not entirely comparable as it was done with co-located teams. Similarly, Pissarra (2005) studied the effects of anonymity in idea generation sessions using electronic brainstorming systems (EBS) and discovered that anonymity has a positive effect on group's satisfaction, the number of good ideas as well as the diversity

of ideas. Although the studies suggest that good ideas can be generated anonymously and in asynchronous settings, multiple researchers have stated that social interaction is linked to better performance. For example, Lahti et al. (2004) explain that social collaboration is an important part of conceptualization phases, such as idea generation. The need for verbal, real-time, communication while performing tasks together is an important factor to provide further context of the ideas generated.

Quality and quantity in idea generation

When working on wicked problems or open-ended innovation challenges, teams often aim for a large number of ideas. Quantity matters as in the end only one or a few best ideas are taken forward. "The success of idea generation in innovation usually depends on the quality of the best opportunity identified" (Girotra et al. 2010 p.1). Quality is often related to originality as well as feasibility (Rietzschel et al. 2010). Teams aim for quantity to have a higher probability to produce extreme ideas, which in fact are quite rare. Despite the fact that there are thousands of techniques developed for creative thinking (Lau et al. 2009), the evaluation and selection of the best ideas may be difficult. Suitably, Girotra et al. (2010) state that the focus of existing brainstorming literature has been more on the creation process rather than the selection process in which teams try to identify the ideas that should be taken forward.

Girotra et al. (2010) compared teams that work together simultaneously to teams that work in hybrid structure in idea generation and idea selection phases. Hybrid process refers to a structure in which team members first generate ideas individually and only after that work on the ideas together. The researchers discovered that teams in hybrid structure produced ideas of better quality as well as higher quantity. Therefore, the overall quality of the few best ideas was significantly higher compared to the ideas of teams that worked simultaneously the whole time. The researchers claim this is due to the fact that the hybrid process generates a lot more diverse ideas in total. This seems to be a promising finding for GVTs as often team members partly work on their own and simultaneous virtual idea generation seems to be a difficult task. However, this study also showed that choosing the ultimate best idea was difficult. Although teams in hybrid structure performed better in producing the best ideas as well identifying them, it was discovered that all in all they were still weak in assessing the quality to choose the overall best idea. This finding was similar to another study (Rietzschel et al. 2010) in which it was discovered that even though the team would be able to generate

excellent ideas it does not necessary lead to selection of these ideas.

2.6 COLLABORATIVE DECISION-MAKING

In collaborative design projects, decision-making should also be done collaboratively. Unfortunately, there is only little research done on decision-making effectiveness in design teams, although it is a critical activity (Yang 2010). Studies on geographically distributed decision-making in the field of design are even harder to find, although research exists in other areas. For example, Schmidt et al. (2001) studied the effectiveness of decision-making in new product development (NPD) projects, and discovered that virtual teams make more effective decisions than co-located teams or individuals. Taking multiple varying perspectives into account might lead to better assessment, but also to a more complicated decision-making process. In design projects particularly, decision-making is often hard as problems are ill-defined and therefore, there might be multiple potential, equally acceptable solutions to choose from. In design projects, especially in distributed settings, the solutions are often visual and therefore, can be interpreted in many ways. Cultures, backgrounds, and experiences shape the way we think. Moreover, it is also hard to assess the concepts by using traditional matrices or measurements, commonly used in other industries, since the criteria are usually approximate (Keinonen & Jääskö 2004 pp.59-60). Therefore, a qualitative method of analysis is commonly used. Acknowledged by Keinonen & Jääskö (2004), design concepts are diverse and therefore, there are no specific pre-determined measurements that can be directly used. Holistic evaluation approach is needed in which the full potential, including attributes such as feasibility, viability, technological assessment and user experience, will be explored.

Yang (2010) compared two different styles of making decisions by using structured methods and discovered that building consensus in design teams takes more time than single leader decision-making. Including everyone's opinions to formulate common decisions slows down the process. However, reaching a mutual agreement is often perceived as more satisfactory as the quality of the decisions are seen better. High levels of social interaction and trust between team members has a positive effect on this process (Larsson 2007). Satisfaction regarding decisions is also linked positively on motivation, which affects teams' future collaboration. Still, as Yang (2010) noted,

building consensus in collaborative virtual settings is presumably even more difficult than co-located collaborative settings.

2.6.1 Selection Criteria

As discussed in the idea generation chapter, the selection of the best ideas is often challenging even though there might be multiple good options to choose from. Rietzschel (2010) discovered that employing specific criteria might be beneficial in terms of evaluating and choosing the best idea. However, choosing the "right" criteria might be tricky per se. A good criteria is encouraging, easily understandable by everyone, and suitable for versatile evaluation (Keinonen & Jääskö 2004 p.61). Unfortunately, there are no universal agreement on which basis the decisions should be made (Holm 2006). Moreover, in multidisciplinary teams, it might be hard to find commonly accepted criteria as people tend to have different perspectives on what is seen as a satisfying outcome. Different backgrounds, knowledge, and skills might lead to various views on what the team should value. However, multidisciplinarity can be beneficial in terms of making better decisions. As Keinonen & Jääskö (2004) suggest, good evaluation requires diverse thinking, experts from different fields, to be able produce comprehensive evaluations (p.61).

2.6.2 Values in decision-making

Alongside with knowledge and skills, values play an important role for designers in decision-making processes (Trimingham 2008). The solutions are not chosen based on scientific facts but some other "judgment" in which values have an impact on the decision (Coles & Norman 2005). Similarly, Holm (2006) argues that design decisions and evaluations are based on values more than on facts. A satisfying outcome may not be based on metrics but personal values, including attributes such as emotions, impact, aesthetics, and usability. Individual's values also affect the way features and different aspects of the project are prioritized (Holm 2006). Moreover, personal preferences also influence the selection process as people tend to strongly prefer their own ideas (Nikander et al. 2014; Rietzschel et al. 2010). A self-generated concept might be seen to fit the criteria better than it actually does. Also, concepts that are seen similar to the ones created by the designers themselves might be preferred (Nikander et al. 2014). Knowing what lies behind one's decision might be difficult to identify as well as to communicate. Suitably, Coles & Norman (2005) point out that what appears to be a designer taking a guess, may be something much more. Therefore, it might be fair to state that, in

collaborative projects, team members should be able to communicate their values and motivation to others. Formulating common criteria could be beneficial for the whole decisions-making process, especially in distributed settings.

2.6.3 Decision Rationale

"Design rationale is a way to support design communication among designers" (Du et al. 2012, p.112). In global virtual teams it might be hard to understand what drives others toward certain decisions, especially if the team consists of people from multiple disciplines. A rational decision for one designer may be considered completely irrational for someone else (Holm 2006 p.291-292). Due et al. (2012) state that in virtual collaboration, designers should find ways to communicate design intents, which means giving additional information related to concepts or proposed solutions. These intents provide further context and define the reasoning behind the decision made. Referring to previous chapter, one factor influencing the preference effect might be the lack of equal understanding on all ideas. This was hinted by some of the participants in a study conducted by Nikander et al. (2014 p.492), although clear proof of the effects was not discovered. In order to produce effective decisions, all concepts should be presented in a way that enables versatile assessment (Keinonen & Jääskö 2004 p.61). Hence, if ideas are not understood equally or they are communicated unevenly, does that affect the decision-making process? As mentioned by Du et al. (2012), evaluation during task performance is difficult, and often the consequences of a decision can only be seen later. Therefore, it might be fair to state that communicating the concepts equally as well as the rationale for them is critical.

2.7 A GLIMPSE OF FUTURE TECHNOLOGICAL DIRECTIONS

Future technologies, such as augmented reality and collaborative virtual environments (CVEs), are expected to offer great possibilities for the collaboration of distributed design teams. Virtual Worlds (VWs) or collaborative virtual environments are 3D environments in which users can interact, socialize, and create, through avatars together with other users by using a desktop computer (Koutsabasis et al. 2012). These platforms allow real-time, synchronous, collaboration between designers as well as offer immersive experiences (Rosenman 2007). For example, a tool called Second Life (SL) has been actively utilized by educational institutes to support the designing of learning spaces and activities (Minocha 2010). Nonetheless, possibilities of Virtual Worlds in collaborative design have not been fully exploited, but researchers are showing growing interest on the use of VW platforms in distributed design.

The benefit of VWs is a great number of functions and features integrated under the same roof; both synchronous and asynchronous tools that can facilitate collaboration in different phases of design processes such as instantly communicating ideas and evaluating them (Koutsabasis et al. 2012). Moreover, there are possibilities to build on the existing functions to modify the space according to user's needs. VWs can be used effectively for visualizations, real-time simulations, manipulation of 3D objects and full immersion as well as embodiment of users instead of just observation of the actions (Koutsabasis et al. 2012). This enables designers to fully be immersed in the design space while communicating with others.

Koutsabasis et al. (2012) discovered that the use of VWs can offer a potential virtual co-creation environment for effective collaborative design activities, especially suitable for conceptualizing phases and evaluation of concepts. Furthermore, what seems to be an important finding is that VWs can increase awareness of various activites and team's progress. However, being a relatively new platform, the active use of VWs in distributed design activities has not been researched enough in the context of realistic and complex design projects (Koutsabasis et al. 2012).

03 DESIGN RESEARCH CHALLENGES IN ME310

03 DESIGN RESEARCH CHALLENGES IN ME310

"Fail fast to succeed sooner"

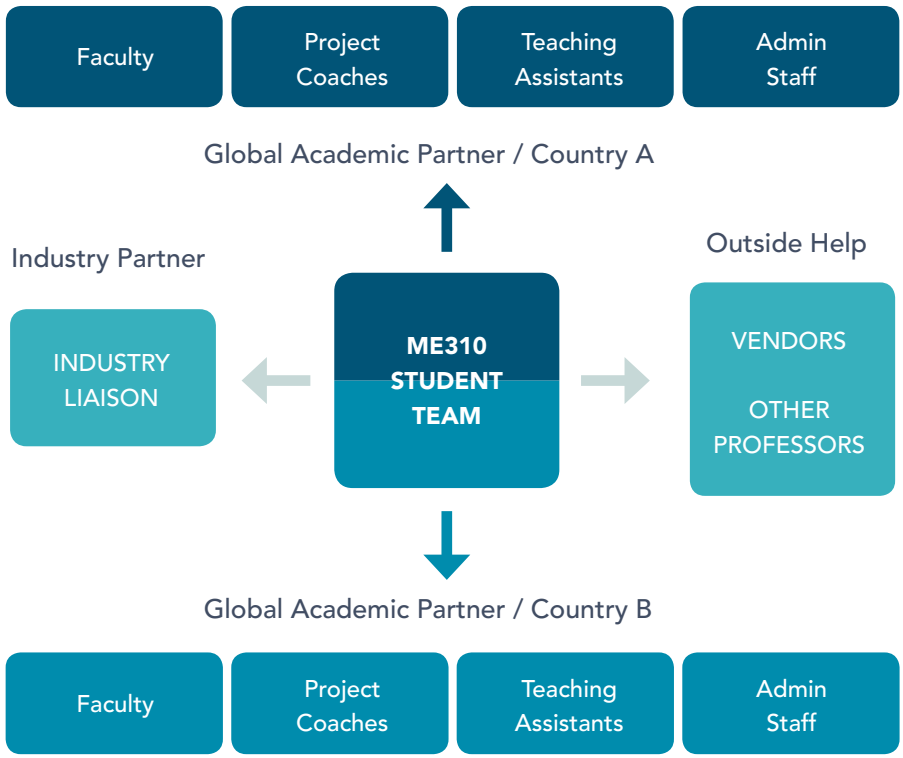
(An utterance commonly used by ME310 teaching staff)

Aim of this section is to describe and document the problem space of this thesis. Firstly, the context of this thesis is introduced. Secondly, a quick overview of the design research methods will be given. Thirdly, a detailed analysis of the research findings will be presented. Lastly, the potential directions for the development phase are presented in a form of design drivers.

In the heart of this thesis is a course called Mechanical Engineering 310 (ME310). The name refers to a standard course code originating from the faculty of mechanical engineering. ME310 was originally created at Stanford University over 40 years ago and it is now taught in more than 15 leading universities around the world (also known as the SUGAR network). Today, ME310 is a multidisciplinary Master-level global design innovation course running also in Aalto University. The academic year-long course teaches product development through processes developed by Stanford University and IDEO . According to Carleton & Leifer (2009) ME310 has developed a strong reputation in Stanford University and the impact it has on other courses as well as universities is significant.

ME310 is a course in which the students work in multidisciplinary teams of 3-4 people, partnering together with another school from the program for eight months (Figure 10). The teams usually consist of 6-8 students located in two or three different countries. Various backgrounds, cultural differences and time pressure simulate real-world settings as students face challenges that are comparable to those confronted in working life.

Figure 10: Network view of ME310, modified from Carleton & Leifer (2009)



ME310 is based on Problem Based Learning (PBL) which means that students tackle real-world problems proposed by various industry leading companies (Carleton & Leifer 2009), such as Nokia, Audi, and UBS. Starting from an open-ended design brief, student teams tackle real world design challenges by going through an iterative learning cycle (Figure 11 on page 46). In the beginning of the course students explore the problem space by doing extensive needfinding and benchmarking, using several design methods, such as interviews, observations, and user personas. After discovering specific user needs and problems to be addressed, the teams create several concepts and prototypes. Proposed solutions are validated through thorough user testing. In fact, users are in the core of the process as different user engagement activities have proven to have a positive impact on the final outcome (Leifer & Steinert 2011). Therefore, user involvement is required in all phases of the process. In the end, the teams need to converge and decide on the final solution that will be built by the team. The outcome of the project is a proof-of-concept prototype, which is showcased in the final prototype expo in Stanford University. Teams have the freedom to address the problems in a

way they see appropriate or even redefine the design brief if necessary. Therefore, the solutions may sometimes be positioned relatively far from the scope of the original brief, but nonetheless, offer disruptive answers to real problems. This is also the core of wicked problems as multiple, equally acceptable, solutions may be presented to one problem and often the answer might be completely different than expected (Buchanan 1992).

The teams have to cope with unique challenges set by the course process and geographically distributed locations of team members. What is also special in these teams is that there are no team leaders or predetermined roles. It is believed in the course pedagogy that high performance teams function horizontally rather than hierarchically. Researchers also agree that shared leadership may be an important factor in predicting team effectiveness (Pearce 2002). In ME310, all team members are equal and tasks are usually divided based on people's backgrounds and skills. However, "Role ambiguity occurs more frequently in groups that do not have a leader, or have a "laisser-faire" type of leadership" (Curseu et al. 2008 p.633). As noted in the theoretical background, this creates challenges in team dynamics as well as communication and collaboration. Moreover, since the course is multidisciplinary, the process is based on design methods, and the challenges have not been researched in the field of design, this course offers an interesting starting point for this thesis.

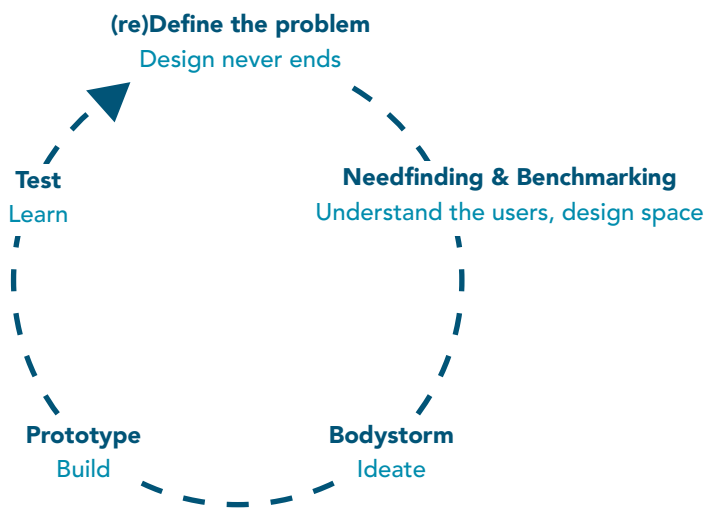


Figure 11: Stanford/IDEO Design Process used in ME310 (Source: ME310 Teaching Material)

The home base of ME310 is the "loft", which in Aalto University, is located in Aalto University Design Factory. A dedicated space is a key factor in learning (Leifer & Steinert 2011). In ME310 it means that one physical space offers an agile workplace, which is suitable for various types of learning: prototyping, team meetings, and idea generation sessions. As stated by Leifer & Steinert (2011), the aim of integrating all the different features under the same roof is to minimize the barriers to accelerate learning. Moreover, in the ME310 process the focal point is on rapid prototyping. Prototypes built should be tangible and low resolution (especially in the beginning) to be able test the ideas, assumptions and hypotheses quickly (Leifer & Steinert 2011). "Failing faster to succeeding sooner" mentality is highly encouraged by the course staff. This means that all ideas should be prototyped and tested quickly to confirm or reject a hypothesis, and to get feedback from real users.

3.1.1 Why ME310?

There are a couple of other factors that make researching the collaboration of these In addition to the above, there are additional factors that make researching the collaboration of these teams suitable for this thesis. First, these teams do not have any restrictions concerning communication and collaboration tools used during the project. Companies are usually using their own preferred set of tools due to privacy. ME310 student teams are free to use tools and methods according to their needs. Second, these teams are more flexible in trying out new ways of working. Quite often the teams change their ways of collaboration during the process: the tools that do not work are abandoned and new tools and methods are adopted if necessary. Third, these teams are eager to learn and to improve their collaboration. As already mentioned, in PBL one of the goals and outcomes are self-directed and motivated students (Carleton & Leifer 2009). This is evidently the case in ME310 as students who take the course are fully immersed in their projects and often describe it as the best learning experience during their studies.

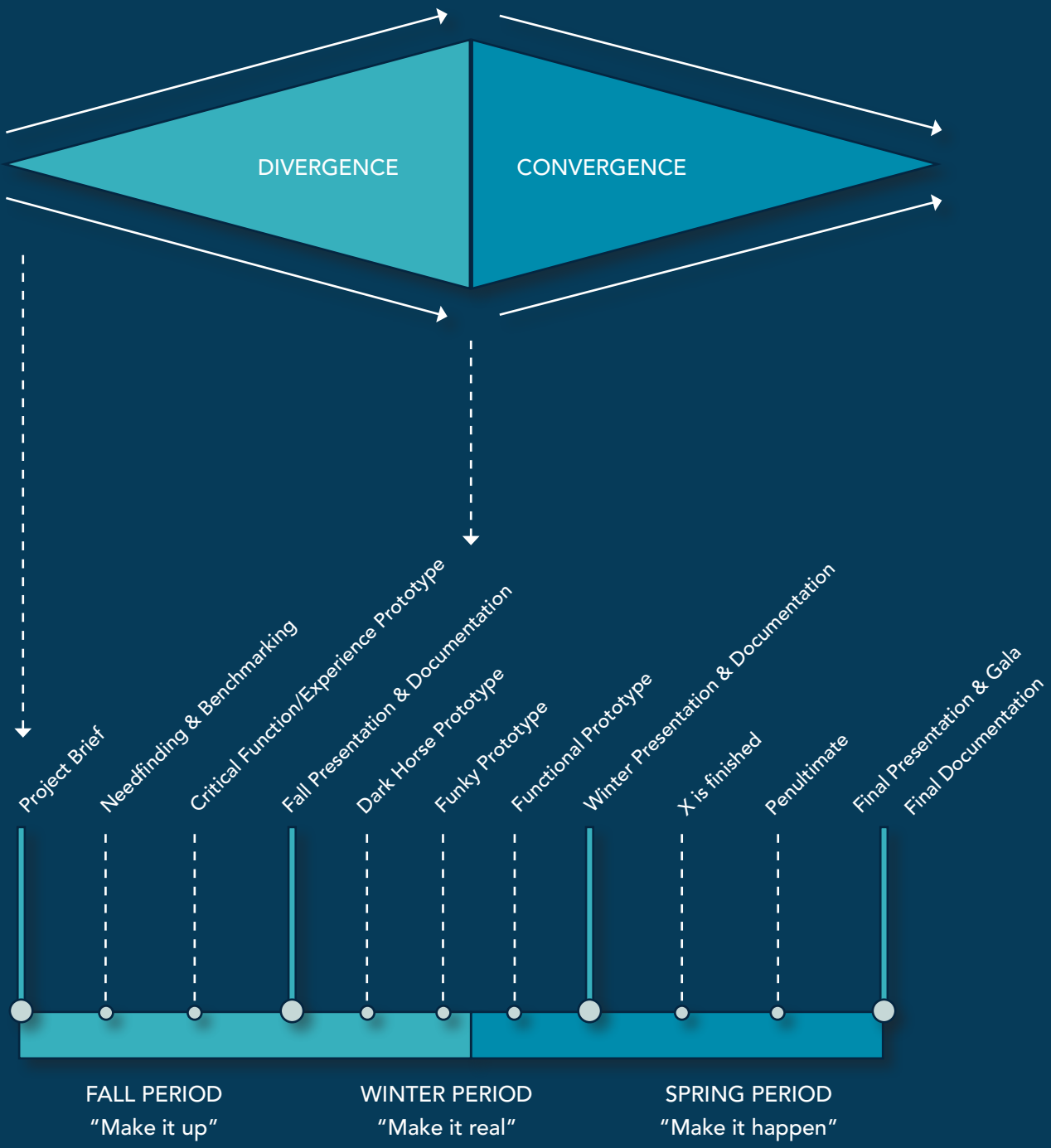
ME310 also differs from other courses because of the extensive support network available; coaches, professors, course alumni, industry liaisons, and visiting lecturers are all there to guide students during their projects. The teaching assistants and instructors are usually former students, who are familiar with the process and potential obstacles, as they have gone through the process themselves. Based on my own experiences, the course staff and coaches are of great help when the teams are struggling to

move forward or need guidance in their process. The teaching team is also in charge of weekly lectures and workshops, in which supportive tools and methods are introduced to the teams. The progress of the teams is reviewed weekly by having small group meetings (SGMs) with the teams, and large group meetings (LGMs) with the whole class. In these sessions, the teaching team provides feedback, offers guidance, and challenges the teams to think and act beyond their comfort zones.

3.1.2 ME310 Timeline

As can be seen in Figure 12, ME310 has several milestones and stages students need to complete. The process is not overly strict and actually offers a lot of flexibility. The structure is followed in each university to synchronize the teaching schedules and deadlines. There may be variance in the specific methods, such as content of lectures, as all coaches have their personal way of teaching. The company design briefs are open ended and therefore, students need to learn how to deal with high levels of ambiguity and be able to trust the process. The overall structure, that follows the divergence and convergence model, is divided into three main phases that include several smaller steps. Autumn is all about exploring the problem space through need finding and benchmarking activities. Winter is dedicated for prototyping and user testing. After this period students should decide on the final direction, since the spring quarter is all about making it happen. All three periods include several smaller milestones and deadlines that are mostly related to prototyping activities. All in all, the course is extremely intensive and offers a good structure to explore the problems given in the beginning. As stated by Leifer & Steinert (2011), certain activities, such as high user involvement at all stages and iterative prototyping, increase the probability of success.

Figure 12: A year of ME310, Divergence/Convergence process and major milestones (Source: ME310 Teaching Material)



3.2 RESEARCH METHODOLOGY

3.2.1 Primary source of data: interviews

What & Why

In order to understand the students' behavior and practices, a qualitative research method was chosen. "Qualitative research design is a research method used extensively by scientists and researchers studying human behavior and habits." (Martyn Shuttleworth 2008). This approach is useful when a simple yes or no is not an adequate answer. To be able to fully understand what are the most significant challenges GVTs are facing in the context of ME310 course, and what are the reasons for these problems, I chose to proceed with thematic semi-structured interviews. These interviews were conducted to obtain primary source of research data.

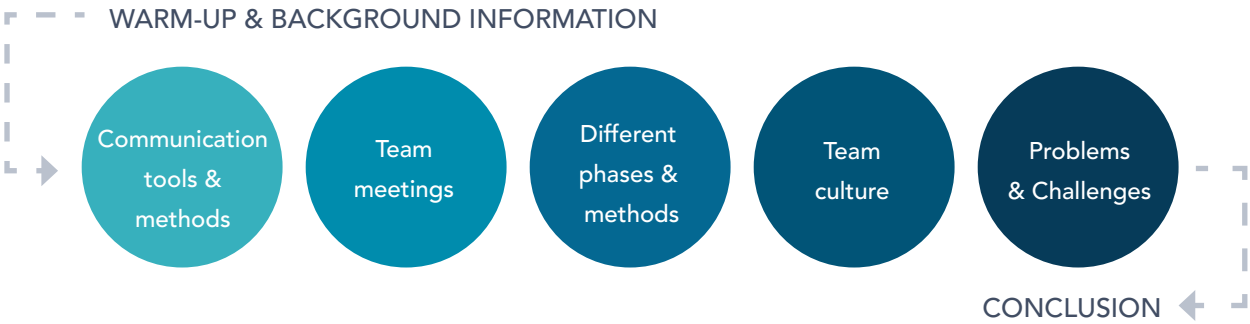
In a semi-structured interview the researcher has a predefined framework of topics to discuss, but as it is not fixed, it allows tailoring of questions on the go based on the participants answers. The benefit of semi-structured interview is the flexibility it gives for the discussion. Due to the complexity of the processes and diverse ways of working used during the course, interview was also seen as the only viable method to begin the research phase. Moreover, interviews offer the possibility to get as much information about different working methods and tools required for different types of projects and also, to understand what are the most critical challenges that should be addressed.

Who

Altogether 16 interviews were conducted between August and October in 2014. All the participants were ME310 alumni who have completed the course in the years 2012-2014. In addition, some of them are now or have been part of the course teaching team. The participants come from different cultural backgrounds and countries as well as various disciplines (design, business and engineering). To protect the privacy of the participants and the details of the projects, the names and companies will be disclosed. In addition, some of the teams have signed a non-disclosure agreement (NDA) with their project sponsor, which restricts me from sharing detailed information related to the projects. Therefore, an anonymous list of participants and their backgrounds can be found from Appendix on p.135. Most of the interviewees completed the course at Aalto University and five of them completed the course in other partnering universities. In total, 13 different industry projects were represented by the participants, project briefs

coming from various types of companies, such as UBS, Bayer, and Audi. Therefore, the project briefs and outcomes had significant variance: some projects were more service oriented with focus on digital prototype outcomes and some projects concentrated on building tangible product-based solutions.

Figure 13: Interview themes



How

The interview structure was divided into five main discussions themes: communication tools, team meetings, different phases of the project, team dynamics, and, communication problems (Figure 13). The purpose of these themes was to guide the conversation giving it flexibility at the same time. To stimulate the conversation, an illustration of the course timeline was printed and showed to the participants (Figure 14). This figure acted as a reminder of the different phases and turning points and enabled the participants to refer to certain moments of the project easily.

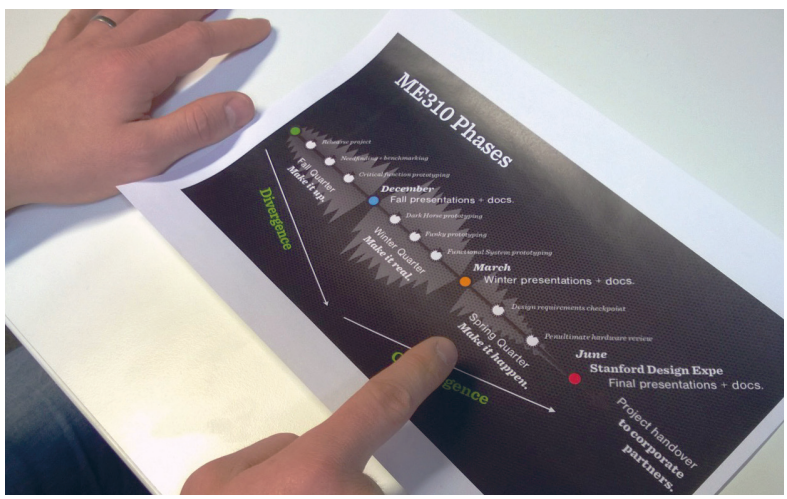


Figure 14: Timeline used in the interviews to support the discussion

Depending on the participants, some themes were emphasized and discussed in more detail. Nonetheless, all mentioned areas were covered in each interview. A detailed list of guiding interview questions can be found from Appendix on page X. Each interview was recorded with a permission that was asked before the interview started. Few of the interviews were completed remotely using Skype. Each interview lasted approximately an hour: the longest was 75 minutes and the shortest approximately 45 minutes. Detailed transcripts were created from each interview before starting the analysis.

3.2.2 Processing the data

One common problem with qualitative research approach is the amount of data that the researcher ends up having in the end, which means that managing it is a complicated task (Walker 2004). This was noted during the process as the material had to be processed in multiple rounds to be able to formulate a holistic picture. Prioritization was also needed as some of the findings had to be left out due to falling outside the scope of this thesis.

The analysis started by clustering the data into different categories based on similarities, code words, and characteristics. Preliminary themes were formed to understand the overall picture and which areas were emphasized more than others. One important step was to recognize all the data that belongs to the same subgroups of already created themes (Aronson 1994). It was relatively easy to find similarities and patterns that kept repeating in the interviews, although there were also contradictory findings. Therefore, all categories defined include positive and negative findings, which were identified. The aim of the analysis was to identify the most significant challenges and problems student teams face during their project. Also the goal was to find out if there were any practices or methods that lead to successful experiences, such as improved collaboration, which would serve as inspiration for the development part of this project. The results as well as the full categorization will be described further in chapter 3.3.

3.2.3 Secondary data - Exploring students' documentations and observing behaviour

All ME310 teams create extensive final documentations in the end of their projects. These reports contain detailed information about the teams' projects, progress, and methods. Therefore, I chose to examine previous documentations as secondary source of data. In total, 11 documentations from the years 2012-2014 were explored to link

practical examples to findings from the interviews. The teams have predetermined guidelines on how the structure of the documentation should be organized and what kind of information these reports should contain. However, all teams have had the freedom to modify the structure and contents according to their needs and wishes. Naturally, the documentations do not tell the whole truth about the teams' journey; most problems related to the process are not mentioned, all methods are not reported, and reflections on working methods are missing. The findings will be presented in chapter 3.4.

Figure 15: Browsing teams' documentations

Observations and personal experiences

Due to personal history with ME310 as a student as well as a teaching assistant it is extremely difficult to forget personal experiences. Therefore, it is fair to say that my history and experiences with current students has had an impact on this thesis. To be clear, when I feel that these experiences have influenced the progress, I try to mention that explicitly. During this process I have had the possibility to observe current ME310 (class of 2014-2015) students in Aalto University. At the same time I have been the assigned coach to one team in particular. The observations and discussions with the students have been useful to be able to validate my hypotheses and assumptions. Moreover, even though I completed the course several years ago, my memories of my project are still relatively fresh. These experiences have influenced the process of deciding which direction to select for the development phase as well as the concept creation process.

3.3 INTERVIEW RESULTS

The findings from the semi-structured interviews are divided into 8 different categories (Figure 16). This section contains preliminary analysis on these categories and quotations from the participants to emphasize and demonstrate the findings. Some categories will be left out from the overall analysis due to falling outside of the scope of this thesis. As can be seen from Figure 16, the analysis and findings are divided into three different classes: a) Tuning in, b) Creation of shared understanding, and c) Design tasks.

> *"It is challenging to use the potential of the team. It's easy to spend so much time and energy on communicating and sharing of things, which would be a lot easier if people would be by your side."*

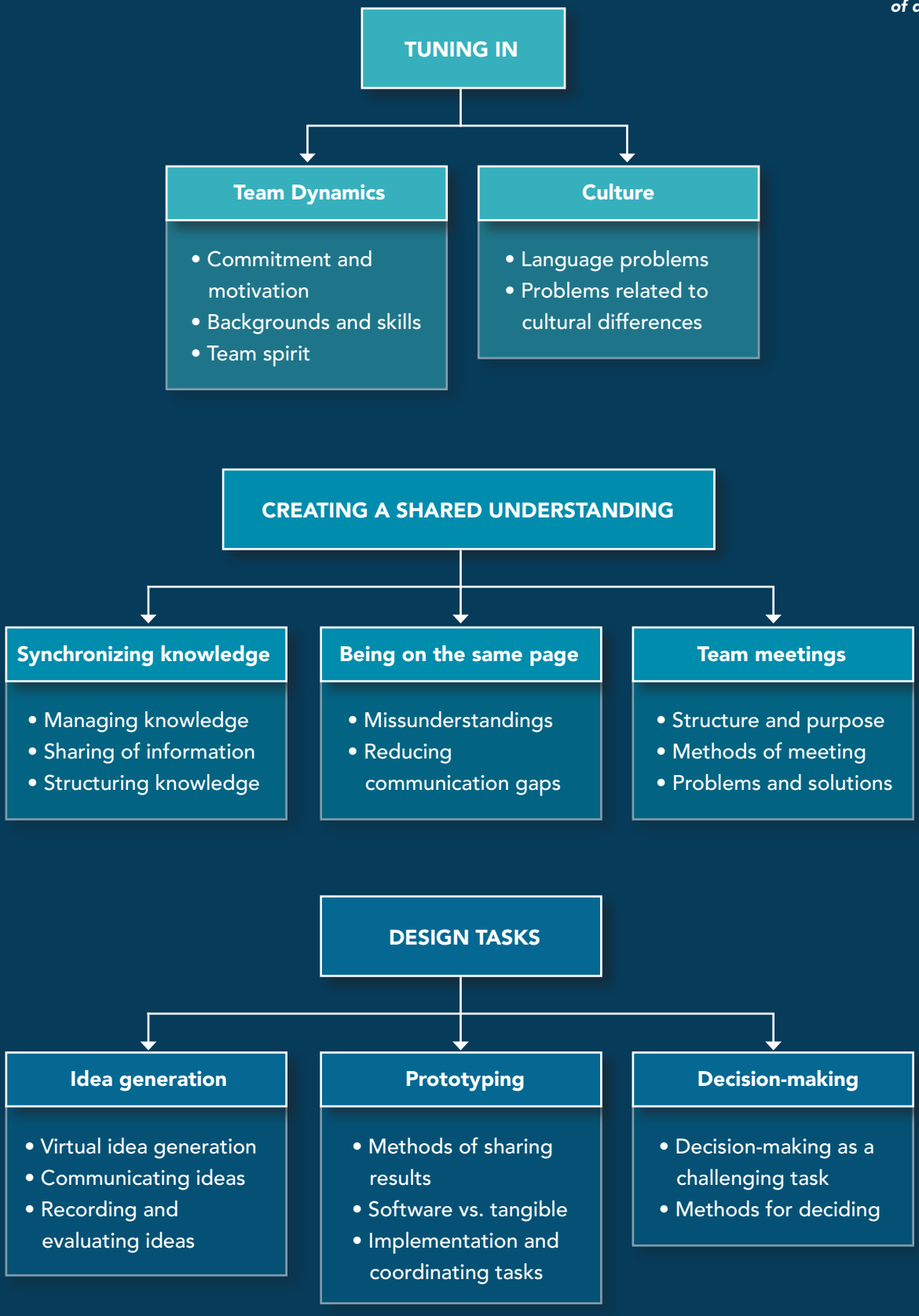
Before introducing the findings, it is important to mention one recurring factor. When I asked about the most significant turning points of the project, all participants mentioned the times when the whole team was together in a same place. Usually, this happens two or three times during the process: in the beginning when the project starts, in the middle during prototyping or convergence phases, and in the end when the teams come together to finalize their solutions for the final expo. All the participants mentioned how easy and efficient it was to work with the team face-to-face compared to the remote phases of the project. Often it was stated as an eye opening experience in to be able to see things in a same way and to refine common goals. In fact, it was mentioned several times that understanding others' passion remotely is extremely difficult. Most participants also compared distributed collaboration to traditional teamwork and stated it being extremely frustrating and inefficient. Therefore, one notable question to seek answers for is: how to make distributed teamwork both enjoyable and effective?

3.3.1. Team dynamics

Commitment and motivation

Different levels of commitment and motivation caused problems for some of the teams. Honest communication from the beginning can help to prevent some of the challenges arising from these factors. If schedules and personal motivation are not communicated to all team members early it will most likely lead to tension and small conflicts later on in the project. Also, workload might no be evenly distributed if some team members

Figure 16 - Main classes, categories and sub categories of data analysis



have several other commitments. This problem is common in ME310 because of different course requirements in different universities. However, not all teams see this as a problem because of high levels of personal motivation. In many cases, team members are willing to contribute more than is expected from the university's point-of-view.

> *"In the beginning the workload was not divided equally because of schedules and commitment issues."*

Often team members also have varying expectations regarding the outcome of the project. Some are more ambitious than others, wanting to aim beyond expected and some are satisfied with less ambitious outcome. If these factors are not communicated in the beginning it will most likely lead to frustrating situations, especially towards the end of the project when it is time to converge.

> *"One weakness was different point of views. Some of us wanted to create something groundbreaking... Some were more rational and wanted to create something feasible and useful. But that also gave me some new perspectives of what innovation is – it can also be something small that is implemented well."*

Backgrounds and skills

Skills and previous experiences are factors that highly affect the dynamics of the team. ME310 is a Master's level course, but some students are more experienced than others in multidisciplinary teamwork and product development projects. Naturally, various backgrounds are also related to different point-of-views. At times it is hard to understand where others are coming from and why they feel as they do; what is the rationale or passion supporting their thinking? If there are potential problems those usually come to light in the decision-making phase.

> *"There were different levels of skillsets, which caused problems. For example, one problem was communicating what is actually physically possible with some components. Often one part of the team came up with an idea and then the other part gave feedback saying "you can't do that - that defies the laws of physics". And it was really difficult to do that in a nice way at times."*

Naturally, characteristics and diversity of team members also have an impact on team dynamics. Most of the students felt that having various disciplines and personalities in the team was a strength, although it caused problems at times. As long as the team

was working towards the same goal diversity was not an issue. When people have the feeling of being equal there is a productive atmosphere in the team, which influences the positive overall mood and makes people to be more tolerant to disagreements.

> *"We were quite diverse from a personality point-of-view. Some were really good at organizing things, some were really wild and some were really positive or negative. It was great to have this diversity."*

Team spirit

If the team is able to set a good atmosphere from the beginning it will foster honest discussions and building of trust. Bonding as a team, creating common values and goals is essential. The teams who were not able to do this in the beginning often ran into problems later on. Negative team dynamics may be hard to turn positive and therefore, the way the team begins to work together is important. Team members need to experience the feeling of equality and trust, which will foster openness and an informal atmosphere. Having a good laugh every now and then increases positive team spirit.

> *"They did not want to spend time and bond with us in the beginning. That's why we didn't get the ball rolling."*

When there were conflicts related to team dynamics, those were more easily solved by having a professional attitude. So, even though there might have been an argument, the criticism should never have been aimed at a person but towards a task and therefore, making it easier to solve. Suitably, most participants said that the level of professionalism was high in their team.

3.3.2 Culture

Language problems

Language barriers are common in ME310. The course is taught mostly in English but many of the participants come from countries where it is not that common to speak or learn English. However, all the global collaboration is accomplished in English. The teams that had language barriers stated that it was clearly an issue. Despite the challenges with language, there were no clear indicators that it would have an impact on the success of the project. Nonetheless, in many cases it slowed down the progress and forced the teams to come up with creative ways of communicating, such as increasing the amount of visual means in their communication.

Language skills are also related to confidence. The team members who have stronger language skills may unconsciously take the role of a leader in the team. This works against the aim of being equal team members and therefore, affects the dynamics of the team. It is important to address these issues and encourage all team members to contribute equally. It might require changes, such as stronger team members' behavioral change towards being more patient or visual in their communication and even stepping back slightly from the role of leading. Usually, teams try to address these issues themselves. In some cases a facilitated feedback session organized by the teaching team was needed.

> *"There was a main speaker from each university who naturally took the role of talking the most. We tried to address that and change the culture a bit. The goal was to make every person to say at least one thing in the meetings. But this was pretty unsuccessful, because there were language barriers to deal with and different levels of confidence."*

Problems related to cultural differences

Some teams were more affected with cultural differences than others. Taking the time to understand where others are coming from and how that affects their behavior took time and energy. Some teams later found differences as strength, but it required deeper understanding of the cultures and backgrounds. It was also evident that culture affected more than time difference or language barriers, as stated by multiple interviewees. Based on the findings in this thesis, this is especially related to differences between Asian and western cultures. In Asian cultures people are often extremely polite and somewhat reserved, whereas in western cultures people are more direct. It was also noticed that these factors become more evident in remote collaboration. Some participants said that travelling to the other location and experiencing the culture themselves helped to solve these problems.

> *"The problems we had were definitely related to the cultural differences. The best parts of the culture are also the worst parts. They (Japanese) are so polite, but then again they don't tell what they think."*

> *"Sometimes we (Finns) thought we had a good and productive debate, but the other part of the team (USA) felt like we were in a fight".*

3.3.3 Synchronizing knowledge

Managing knowledge

Managing all the information that was discovered and created during the project is difficult. Moreover, it is extremely hard to synchronize the different knowledge basis of the participants. Many of the interviewees mentioned that there were unpleasant surprises that could have been avoided by talking more openly or creating rules for synchronizing knowledge in the beginning. Most of the teams used several tools for remote collaboration and therefore, information became scattered quickly. Important findings might have got lost because of overflow of information and lack of structure. It was also emphasized that teams were lacking a proper methodology for synthesizing findings and insights. At times, teams thought everything went well but later on discovered the reality being the opposite. Overall, sharing of information and updating everyone is time consuming and requires a lot of energy.

> *"Communication and sharing of information was the most difficult thing for us, although, at the time I thought it went well. At some point it felt like we did not know what was going on because information was so scattered!*

Documenting is a time consuming task and not necessarily the most exciting one. It is common to skip detailed documenting in times of hurry, because of overflow of information, and pure laziness. Moreover, priorities are often targeted towards implementing project tasks and building prototypes instead of documenting. However, lack of recording important findings backfires later as the team is not able to create a shared understanding due to missing pieces of information. Moreover, the teams could be more creative in the way they document their knowledge. Most teams rely on text-based documents, although they could be much more visual or find stimulating ways to share insights. The use of visualizations, posters, or videos could be a good way to introduce one's knowledge to others quickly, which is encouraged by the teaching team. The importance of being able to formulate a holistic picture of all information should be emphasized, as keeping track of reading and understanding information also seems to be challenging.

> *"It's so easy to discuss, but if things were not documented well information gets lost. It's also hard to keep track on who actually reads the documents".*

Sharing of information

Some problems are related to the speed of sharing. It is critical to record or share findings immediately before bits and pieces or relevant information get lost or forgotten. Some participants also felt there was a burden created by "owning the information", which means that a particular person was in charge of sharing information but was not necessarily able to communicate it well enough to others. If a person is responsible for example an interview as well as documenting the insights from it, but can't for some reason share the information to others right away, important findings might get lost. Later on the person who is "owning the information" might see some solutions more valuable than others without being able to say why or making it clear to others.

> *"I think parts of the information got lost because two students had to translate everything (interviews, sponsor conversations) and sometimes there was a delay in doing that. So definitely they had a lot on their shoulders and it wasn't always possible to share the results right away. And if you don't share information immediately it gets lost... So some things that were obvious for them, because they experienced the situation, were not obvious for the rest of the team. Sometimes they assumed that the information was shared and it was clear to everyone when it actually was not..."*

Structuring knowledge

Some participants were able to start reflecting on possible ways of structuring their knowledge. Multiple interviewees suggested having a person being in charge of information exchange. Protocols for sharing and organizing the documents would be needed as well. Also, it might be a good idea to introduce methods to make sure everyone has read all the relevant documents before team meetings to ensure that everyone understands the most important findings.

> *"I would give everything a bit more structure. For example saying that we have templates for sharing ideas from the beginning... and to have some structure for organizing our documents and files, because our Drive got really messy. To have something to share the knowledge with and make sure everyone gets informed about it."*

3.3.4 Being on the same page

Misunderstandings

Surprises, misunderstandings, and small crises are common for all teams. When I asked about changes they would like to make regarding the collaboration, most of them

mentioned that it would be great to be able to understand what drives others towards a certain direction, because it is simply hard to understanding others' passions remotely. This became evident latest in the decision-making phases in which the students noticed that team members valued completely different aspects.

> *"I would like to try to follow their decision-making paths and understand what drives them to a certain path. But it's hard to understand others passions remotely."*

Most participants mentioned they were not always or even ever "on the same page" with the other half of the team. This means that subteams were not updated on each other's progress well enough or they saw the potential directions differently. These gaps became clear when the other part of the team did something surprising or something that was not planned or agreed on together.

> *"One of the biggest problems was that teams were not updated about their progress, not at all. Both teams were not good at communicating this. We noticed this during the making of our fall documentation. At that point we understood that "we had no idea what they were doing and vice versa."*

Often the reasons for these gaps were not clear even in the end of the project. Furthermore, most students had no idea on how to close or reduce those gaps. Many teams struggled with these problems without knowing how to repair them. Some teams had misunderstandings even in the end of the project, which became clear when they noticed that team members were presenting the final concept in a different way.

> *"We had different understanding of things. It's hard to understand how others see things. I'm not sure if you are ever on the same page in project. You think you are but it might be the opposite because people see things differently."*

Reducing communication gaps

Some teams tried to close the communication gaps by doing more one-on-one sessions. They discovered that it was easier to understand others opinions by having a more elaborate or intimate discussion. One-on-one conversations are also more effective in terms of speed and being able to fully concentrate on what the other person is saying.

> *"The purpose of one-on-one calls was really to capture one's feeling and to see what their view was, and to be empathetic for that person, to make the person*

feel included. Usually, we were discussing about the same things as in those big meetings but just more on a personal level... I think it was super useful."

Some teams discovered that being visual or tangible reduced some of the misunderstandings. Synthesizing information in a visual way might help to prevent misconceptions as pictures always tell more than verbal descriptions. Building a prototype is even more effective way of conveying a message, as tangible objects are easier to understand in similar way by everyone.

"We always wanted to show as much as we could – we were trying to keep things visual when explaining what was done. For example, we visualized all the interview findings. It was better than being verbal, because people were tired, and the connection broke every now and then..."

3.3.5 Team meetings as the main point of sharing information

Structure and purpose

Most of the teams tried to have weekly team meetings via video conferencing tools with all members present at the same time. Usually the discussions lasted approximately an hour. The purpose and goal of the meetings was the same for all teams. First, updating each other on what has happened during the week. Second, showcasing what was done, if possible. Third, having discussions about next steps. And last, making decisions. All in all, the meetings were stated being long and unproductive.

"The purpose of the team meetings was usually to update each other on what has happened. Sometimes we had to make decisions and so those were the long meetings. Because of that distance it just takes forever – I would like to know what makes Skype meetings so different from real life meetings. But there is that difference. So at some point we realized that it is more efficient to first talk in smaller groups and only after that come together to make the meetings a bit shorter."

"Hangouts worked well for the purpose of seeing each other's faces. It didn't work well for communicating ideas and acting up upon them, or really making decisions."

The teams did not have notable requirements for the environment in which the team meetings were held. In most cases it was enough to have a silent room or a corner, a computer or two, a whiteboard or a notebook, and a good Internet connection. Only the

groups that were working with Chinese students had a requirement of using a video conferencing tool called LifeSize, which is the only tool that works smoothly in China. Usually, the teams had a clear routine for organizing the meetings: the discussions were held at the same time every week. Some teams structured their meetings by creating agendas and deciding hosts for the meetings beforehand. Based on the results of this study it is important to give the meetings a structure or at minimum define common goals to keep the discussions productive and to the point.

> *"Communications improved during the year. In the beginning it was hard. We did not reach our goals in Skype meetings, because the meetings were not structured. This problem was solved by creating an agenda as well as deciding a host for the meeting and someone was always managing time in meetings."*

In meetings, the teams focused on essential matters such as updating each other. Consequently, there was not much time left for proper discussions, reflections or giving feedback to one another. Regarding the process, it would be extremely helpful to complete these sessions on a regular basis. One common problem ME310 teams experience, especially in the beginning of the project, is that in practice they have two separate teams instead of a one united group. More effort towards sharing thoughts to become a tight-knit team should be spent. Therefore, it could help to structure the meetings differently, leaving more time for discussion and feedback.

> *"One hour is quite short for a meeting. There's no time left for discussion after presenting what was done, which makes it impossible to give feedback. And the down-side is that if you don't give feedback right away you forget it."*

Methods of meeting

One finding was that communication in team meetings was mostly verbal. Teams could be more creative in their meetings to keep the information flow interesting and effective, especially because the amount of information to be shared. In fact, many of the participants described their meetings being frustrating, because it is difficult to stay alert and proactive over extended periods of time. Modifying objects or documents simultaneously was tried by some teams without notable success.

> *"Communication was mostly verbal in meetings. Every now and then we tried to edit a common word document in meetings (e.g. scheduling), but I thought that was not efficient. People could have done that in advance and the document could have been reviewed together in the meeting."*

Preparation, such as sharing and reviewing files beforehand, is critical. For some participants, lack of preparation, participation, and efficiency made the meetings feel unproductive. There was also confusion related to what should be shared and what is the reason for it. Most participants mentioned that all the meeting material was uploaded online on time, but not necessarily reviewed by all members. Methods for being more prepared could make the meetings more efficient as well as leave time for productive discussions.

> *"A thing I would maybe change...I would create a questionnaire before hangouts asking: what did we do? What were the problems? What is the best thing this team has done last week? What do you wish they would do next week? I would make everyone answer that before the team meetings. That way we would have everyone's expectations on the table. But it should be super simple and fast."*

Problems and solutions

Some people described their discussions as being very formal as for others the tone of the meeting was the opposite. As mentioned before, reaching a productive atmosphere already in the beginning of the project is essential. This also applies to every meeting, especially in remote settings. Fortunately, some teams discovered methods, which enabled them to set the tone for the meetings and also to reflect on how the meetings went.

> *"We had warm-ups in the beginning of team meetings. It was fun - it was team building. It's important not extend that for too long, but if you're in front of a serious one hour meeting it's good to start with some fun. I think this works better with remote collaboration, we never did this when we met face-to-face, because we just didn't need it."*

> *"Team reflection session was done in the end of each Skype meeting, which worked well."*

Spontaneous conversations were prompted by most of the teams every now and then, especially in the later phases of the project. They were seen as more productive than pre-scheduled meetings. Spontaneous calls were often short and focused on a specific problem or task with only two or three members present in the meeting. This approach made the interaction feel efficient. Many of the participants also said that it was easier to connect with the people they were speaking with when there were less people

involved.

> *"In the beginning we had the problem that we had really long calls and we improved on that later on by having calls more often, and also shorter one-on-one calls. Sometimes you can solve issues by having a quick 5-minute call. If you don't solve problems immediately it takes much more time later on to solve them."*

3.3.6 Idea generation and communicating ideas

ME310 design briefs are usually very general and open-ended. In the beginning, due to the complex starting point, the students feel lost and idea generation is difficult even without having to do it remotely. There is high level of ambiguity, which complicates the idea generation process as well as the understanding of others' ideas. Many participants described this phase as being one of the most difficult ones.

> *"The beginning was really hard for us. I keep calling it the scary phase. Because you have to deal with the fear of not knowing what to do."*

Virtual idea generation

Most teams tried virtual brainstorming at least once or twice, but gave up quickly. It was seen as almost impossible to try to ideate together with the whole team, due to several reasons. First, explaining and understanding the idea quickly via video conferencing tools felt slow and tedious. Second, building on top of others ideas did not happen naturally or rapidly enough. As mentioned by some participants, it did not feel like efficient teamwork and often the discussion faded out after presenting ideas. In fact, most teams decided to generate and evaluate ideas in smaller groups before presenting everything to the rest of the group, which seemed to work better. Also, teams felt that it was hard to find proper methods or tools for generating ideas remotely.

> *"Virtual brainstorming was tried out, but it did not feel natural – it felt useless. A tool for this for making it smoother would be good".*

Communicating ideas

Communicating ideas was seen problematic. Based on the interviews, this task was difficult for all teams, especially in the early phases of the project when direction is ambiguous. At that phase a rough idea can be understood in many ways. It is also difficult to understand the full potential of an idea as well to understand the whole

context based on rapid sketches or keywords. Generally, ideas were presented to others by drawing them quickly on a notebook or a post-it and showing it to the computer's camera. Ideas were also described verbally at the same time. Most participants felt this was not adequate in terms of being able to convey the message clearly.

> *"Our biggest challenge was to communicate ideas virtually. Usually, ideas were communicated verbally in team meetings using pictures as support. But quite often a picture on a screen is not adequate to convey the message"*

Recording and evaluating ideas

Recording ideas effectively was also seen as a challenging task. Based on the interviews, videos were described to be the best method for effective communication although they were rarely used in the early phases of the project. More popular method was using templates with pictures, couple of keywords and possibly with some benefits listed. Creating a concept portfolio was seen as a good idea, but not implemented by most of the teams. Therefore, ideas were scattered and unfortunately some of them were quickly forgotten. Moreover, most teams were not elaborate with ways of sharing ideas. Mostly, short descriptions with images or sketches were created, which did not feel sufficient.

> *"Personally I prefer the videos, recording a specific function or an experience... Just a short 10 second video and sharing that... I think that was probably the most effective way of giving the specifics of that idea across."*

There were also problems related to the evaluation of ideas. Most teams did not have specific criteria for evaluating ideas. Also, because of the lack of proper documentation some ideas were forgotten and abandoned without sufficient assessment. These challenges are discussed further in the last part of the analysis.

> *"Well actually the brainstorming kind of worked but then the evaluation of the brainstorming would always be a longer process."*

3.3.7 Collaboration in prototyping phases

In the end of the project when the teams are implementing their final prototype there is significant time pressure. However, in most teams this is seen as a positive feature. This is mainly due to the fact that at this point the project direction is usually already defined and team members get to do what they are best in. Multidisciplinarity and

various skillsets are seen as a great advantage, which usually becomes evident when building the final product or service. The collaboration seems easier because of decreased ambiguity which commonly results in increased motivation.

Methods of sharing results

Most of the teams shared prototyping and testing results by taking lots of pictures and sending those to others immediately by using quick messaging tools, such as Facebook and Whatsapp. The images were also uploaded online with added descriptions. This material was then used to explain findings further in team meetings. It was considered important to share findings as quickly as possible while the impressions are still fresh to not to forget any valuable insights. However, often bits of information got lost or forgotten, because only the essential parts were shared and therefore, it was difficult later on to "get the full picture". Also, sharing testing results remotely was not seen as effective as experiencing the real test setup, because context was felt to have a significant effect on the testing results.

> *"We made really long text documents explaining the prototypes and testing results... Then we tried to filter the most essential things and present those in our team meetings.. After going through this process it was hard to say why this finding was important and sometimes we had completely contradictory findings and results compared to the other part of the team."*

What is problematic is that teams are surprisingly verbal when sharing their findings although they are being encouraged to be visual by the teaching team. "Show rather than tell" is a motto that is not always followed, especially in team meetings. Although there are lots of pictures and visuals uploaded online, these files are not always reviewed. However, it was delightful to discover that some teams tried to use alternative sharing methods. Videos are becoming more common and the teams that made the effort of shooting short videos of testing situations found those extremely useful. These teams also mentioned that videos are by far the best way to communicate prototyping and testing results. Other methods varied from creating short summaries with images, acting out the testing situations, to taking the computer to a prototype during meeting and showing it live.

> *"All countries also made videos and uploaded those to DropBox. Those were definitely useful. With videos you can see really easily what's going on and you can formulate your own opinions easily."*

It is difficult to assess if the teams who tried alternative methods of sharing findings were more successful in the end. However, based on the participants' own reflections of the process trying out different methods, such as videos, improved the collaboration in their opinion. Some teams came up with creative ways of sharing their results, such as acting out the test situation or creating short stories, and they also started reflecting on what was successful during the interview for this thesis.

> *"In the later phase we made videos about specific problems and things which were shared with sub teams, e.g. when I had a problem with electronics I shot a short video using my computer's camera, showing the prototype and explaining what I tried to do... Then the problem got solved. This was a crucial method for the success of our project."*

Software vs. tangible prototypes

There is clearly a difference in building and sharing software prototypes compared to physical ones. Software prototypes were considered as "easy to access and review", which also enabled fruitful feedback and contribution from other team members. With physical prototypes, sharing of information was seen more difficult. With physically small sized prototypes it is possible to show them during the video calls or possible to send them via mail to other countries to be tested. When the prototypes are large it becomes more difficult to update others about the progress as well as problems related to it.

> *"The other part of the team implemented the application part for the final prototype. This was easy to share online and therefore, it was easy to give feedback and contribute to the development. It was "the opposite with the physical part".*

Implementation & coordination of tasks

Even though the final phase was considered as productive and exciting there were still problems with sharing of information and coordinating tasks. Knowing what everyone is working on is critical to be able to produce a coherent and seamlessly integrated outcome. Keeping up good and frequent communication is highly important but also challenging. For efficient progress, workload and task division should be clear to everyone. It might be helpful for this phase to create a method for making visual progress reports that are easy to understand.

> *"The implementation phase when we were still in different places was*

definitely not easy or that productive. You can't really know if everyone is on the same track. You can't check every 20 minutes what people are doing and if they are making progress... and the direction needs to be visible somehow, tangible, in the air."

The division into subteams was seen as a factor that improved efficiency in collaboration especially in the implementation phase. Often, the task division happened naturally based on skills. The people who were working on the same features communicated more to one another, instead of sharing all the information to everyone. If information is reviewed in smaller groups it might lead to faster communication loops and sharing of information.

"In the final phase we had those little teams working on certain things. Someone always took the lead on one topic and then just collaborated with the others, which was important in terms of efficiency."

3.3.8 Decision-making

Decision-making as a complicated task

Most of the people interviewed mentioned that making decisions was one of the most difficult tasks to do remotely. It was also considered as a major weakness. Often the process involved long discussions in which people were defending their own ideas without fully understanding other ideas. In most cases, there is small number of competing ideas and it is extremely hard to agree on a common direction. Naturally, this creates frustration amongst team members. In some cases this phase was seen as a cause of problems that sometimes led to conflicts, mostly because people were not able to let go of their own ideas.

"We tried to avoid making decisions. That was one the weakest points in our project. We mainly did it in the calls and tried to convince each other of one's ideas – everyone were so convinced of their own ideas."

"Making the final decision took a long time, we had lots of discussion and debates. Both teams were prepared to argue with lots of facts and research supporting the ideas."

One of the biggest reasons behind the long decision-making process is that it is hard to understand others' passions remotely. In many cases, all ideas are not understood in equal terms and therefore, some ideas are seen more valuable than others. Concepts

should be communicated to others in a sufficient manner to be able to make decisions everyone can agree on. Also, as mentioned before, there are no team leaders in ME310. This also complicates the decision-making process; all members are equal and therefore, everyone's opinion matters.

> *"The biggest problem was decision-making especially in the end. All of us had ideas - really diverse ideas, but we also had strong opinions, which meant that everybody were convinced that their idea is the best. It was hard to be tolerant, really understand all the ideas, and decide on only one."*

> *"The problem is that everyone needs to be understood in the team. Everyone needs to trust that things will go well in the end no matter what we choose. We also had so many people in the team and we tried to make everyone being ok with the idea, but sometimes everyone doesn't need to be ok with it."*

Methods for deciding

It was mentioned by several participants that they were lacking a proper methodology for making decisions. The rationale supporting the decisions is not always clear if core values are not agreed on beforehand. Decisions might be made purely based on gut feeling. Some team members started reflecting on this already during the process.

> *"Decision-making in was weird... I feel slightly disappointed that we did not have enough good talks and try to decide on things together. Also the rationale behind our decisions was sometimes missing."*

> *"We never agreed on any rules or values beforehand to support our decision-making. I think this could have been a good thing. We could have evaluated our prototypes based on these criteria. It would have made the decision-making more coherent. We did not even vote – that could have made it more democratic."*

Some team discovered methods for deciding by themselves and found those useful. In some projects, prototype test results were clear enough to decide on an idea without having to have debates. However, based on the interview results these cases are rare and most of the teams had several competing ideas.

> *"The final concept was chosen based on viability, desirability and feasibility – and the results were clear enough."*

3.4 KEY FINDINGS FROM DOCUMENTATIONS

3.4.1 Communicating ideas and concepts

After analyzing the interview results it was clear that idea generation and communicating ideas remotely was one of the hardest tasks during the project. Therefore, one clear aim in examining the documentations was to discover what kind of methods teams used for generating and sharing ideas. Based on the documentations, teams used mostly mind-maps, post-its, quick drawings with descriptive titles, and whiteboard pictures for sharing ideas. Only a few slightly more advanced methods were discovered. These means contained more detailed descriptions and preliminary analysis on benefits and problem solving potential (see figure 17 on page 71).

As mentioned in the interview analysis section, teams did not find adequate ways to generate ideas virtually with the whole team. Mostly, ideas were generated locally and explained further in global team meetings. Also, often ideas that were first generated locally were later digitalized and shared by taking pictures and adding those to team's own cloud service to make them accessible for all members. In some cases, more detailed descriptions were added digitally. It was delightful to discover that some teams started categorizing their brainstorming results based on themes, which might be useful when starting to evaluate the ideas. However, most teams did not have a clear structure or scheme to communicate ideas remotely.

Overall, it could be said, based on these findings, that teams are lacking versatile methods of recording and sharing ideas. For the most part, ideas are recorded so quickly, that it might be hard to understand the full picture without detailed explanations, especially on the other side of the world. Moreover, it is extremely hard to review the idea later on or come back to it. Thinking of a situation where the team has tens of ideas, possibly even hundreds, that are quickly drawn and uploaded to a folder with multiple similar sketches, the "golden ideas" might easily get lost. Also, full understanding of all the generated ideas might be hard to reach.

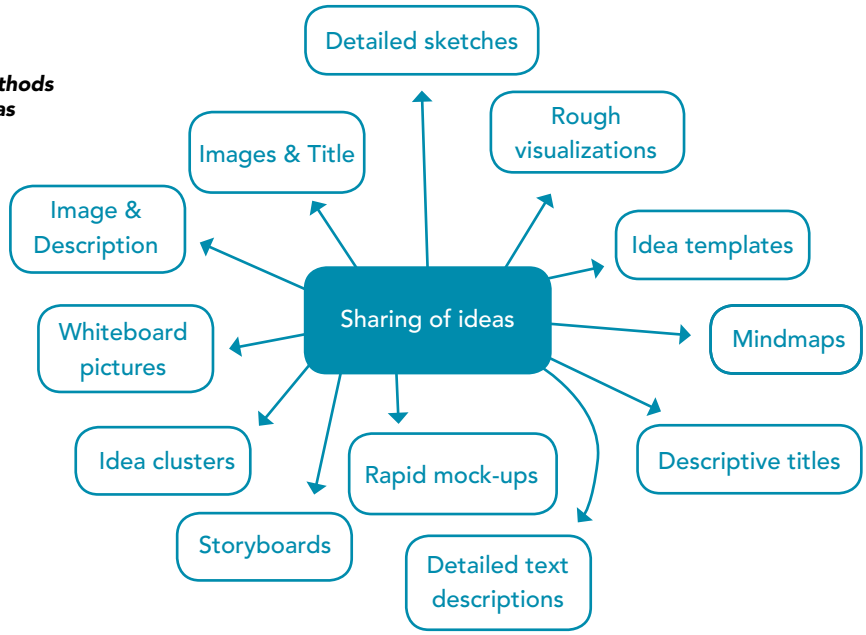


Figure 17: Methods of sharing ideas

3.4.2 Making decisions

Unfortunately, the documentations do not specifically describe how teams made decisions. Only few examples, such as voting and giving scores to ideas based on a certain criteria, were found (Figure 18). Whether or not these methods were successful is not evident. Although it is not explicitly mentioned in the documentations, supportive means for making effective decisions are clearly needed. It seems that teams are somewhat lost in these phases, unless there are ideas that are distinctly superior to other ideas based on testing results. This claim is supported by the interview findings as the lack of methods were notably stated by several participants.

Making decisions as a team remotely is not an easy task. Often, teams first decide locally and only after that discuss with their global partners. Although the team should be a united group, usually the two sub teams in different countries work on different concepts that fall under the same theme, as long as it is possible. Only in the end of the project the final big decision is made together, because it is necessary due to time pressure. Also, based on my personal experiences, making the final decision is a tough process; often it requires time and even severe fights before the team comes to a conclusion everyone is happy with. It might be even fair to say that in some cases, teams try to avoid making decisions remotely. If possible, the hardest decisions are usually made together, if the team has the opportunity to meet face-to-face.

One reason behind the problematic decision-making might be the fact that the team has not been able to create a shared understanding or common goals. Often, team members

defend their own ideas without fully understanding all of the concepts. Different point-of-views and perspectives become evident in decision-making phases. Unfortunately, often it comes as a surprise and therefore, it might be hard to overcome.

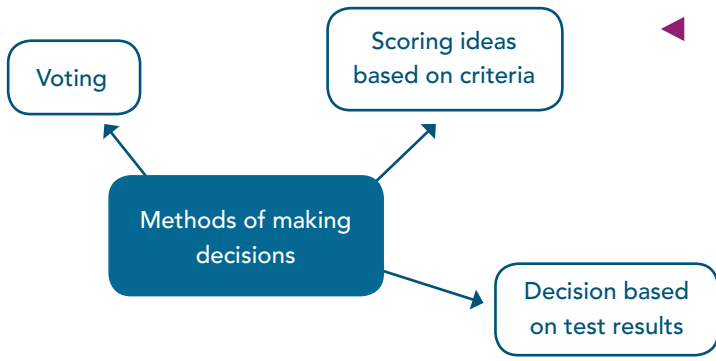


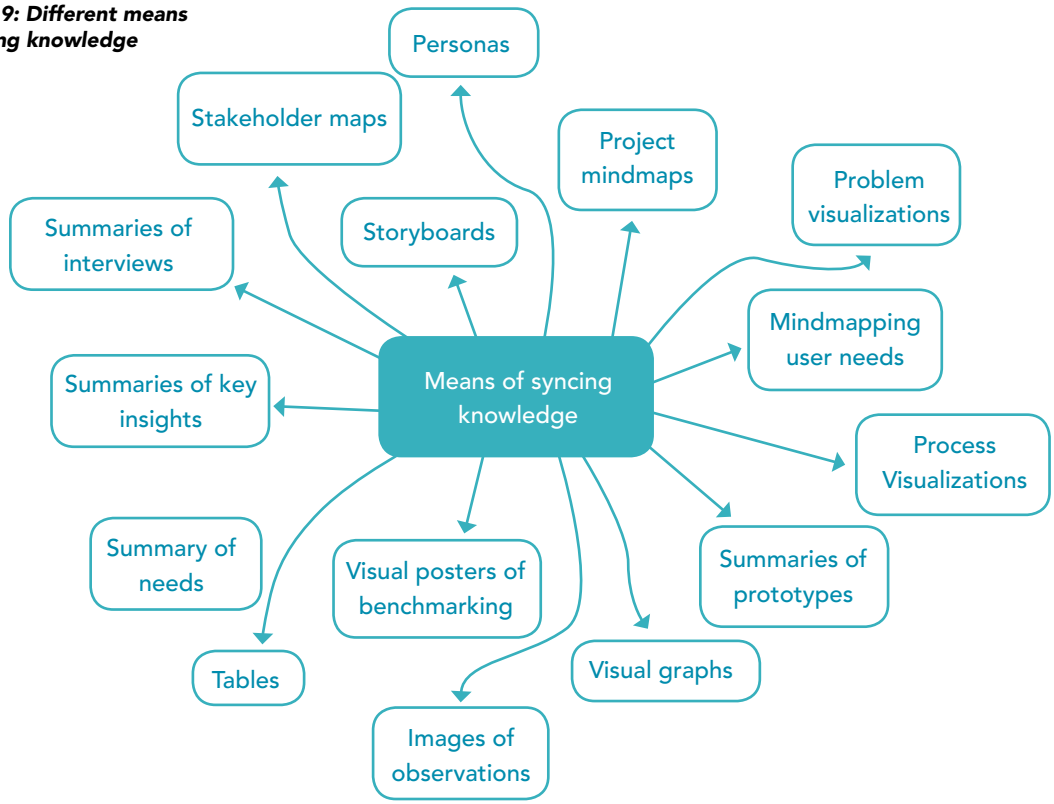
Figure 18: Methods of making decisions

3.4.3 Means of syncing knowledge

In ME310, students are encouraged to synthesize their findings by visualizing them. Transforming knowledge into an easily understandable form is a time consuming task. Based on the documentations, all teams put a lot effort into summarizing their findings to communicate their knowledge. However, as discovered in the interviews, even that might not be enough to convey the message to create a shared understanding. Files may be overlooked or not explored properly. Syncing knowledge seems to be a demanding task especially in the early phases of the project as there is so much new information to process. After moving into the prototyping phases, this gets slightly easier as tangible concepts are more easily captured and understood by taking pictures or videos.

Discovered from the documentations, most common methods of synthesizing knowledge in the early stages of the project were personas, summaries of key insights and discovered needs, benchmarking posters, different types of mind-maps and graphs or tables that summarize findings. Most methods are fairly visual which seems to facilitate the understanding of new knowledge, as pictures are easier to understand. However, the overflow of information quickly becomes a burden.

Figure 19: Different means of syncing knowledge



3.4.5 Communication tools and flow of information

All 11 documentations contained information of communication tools used during the project. Some team started reflecting on which tools were useful for the specific purposes. Overall, the satisfaction rate was quite high, but problems were seen in many areas. Naturally, the reports do not tell the whole truth. In addition to the documentations, interview findings also revealed several challenges related to communication tools as noted in the quotes from the participants below.

In total, 11 teams mentioned 28 different tools in their documentations. On average, teams had eight (8) different tools in their use during the project for various purposes. Usually the selection consisted of at least:

- a videoconferencing tool(Skype, Hangout)
- a cloud service (Google Drive, Dropbox) for file distribution
- an instant messaging tool for quick communication (Facebook, WhatsAppp)
- a project management tool (Trello, Asana, Basecamp, Google Calendar)
- email for official communication

In addition to the selection mentioned above, most teams tried several tools for varying purposes, such as blogging about projects and tools for sharing links. Overall, this seems to be a lot as many of the tools offer similar features. One clear problem mentioned in the interviews was scattered information. Could one of the reasons be the amount of tools used? It was mentioned in the documentations that it was not always clear which tools to use for which purpose. Therefore, information may be poorly distributed and hard to find. Also, lack of guidelines for file sharing structure may be one of the reasons causing these challenges.

> *"We tried to organize all our files couple of times, but whenever something new was uploaded it got a bit messy and people started creating new folders and it was hard to find information... in the beginning we tried to have a structure but it was not completely followed and did not work fully. No one was responsible for this and that was probably one reason why it got messy."*

In the interviews for this thesis it was mentioned that most of tools do not present the teams' progress in a visual way. This is definitely a need related to the development of new tools, although some project management tools are already fairly visual and able to communicate the progress. However, the teams that tried project management tools were not satisfied with them. Most common reason behind this was that these tools require learning and the threshold for starting to use them is high. Moreover, this type of tool does not work if all team members do not use it on a daily basis. This was often the case as some members eagerly started using a tool but others did not see the value and therefore, information was not equally shared and understood. Overall, the lack of collaborative tools that offer simultaneous modification of items, in a visual manner, is evident. Being able to see the same view from all parts of the world is an important factor that needs to be kept in mind.

> *"We tried different task management tools, but those did not work that well, because it required learning and people just did not start using them that well... Probably because no one was in charge of running it in the beginning."*

3.5 DESIGN DRIVERS

After analysis of data, the findings from the design research were synthesized into three design drivers. These drivers work as guidelines and requirements for the development part of the project. As stated by Keinonen & Jääskö (2004) , design drivers are formulated to define clear goals and problems to be solved. Without going into too much detail, the drivers should explicitly describe the vision for the desired outcome.

3.5.1 Tuning in and keeping up

Enable teams to utilize all capabilities and backgrounds of team members to facilitate the creation of common goals as well as successful team dynamics.

As global virtual teams consists of people from different backgrounds and cultures there is a need to understand where others are coming from. Differences such as personalities, attitudes, skills, and previous experiences have an impact on the teams' ways of working. Various disciplines (engineering, business, and design) add up the challenge. This was confirmed by my research, as one clear finding was that individual differences and backgrounds have a tremendous impact on team dynamics, and therefore, the whole process. Team members also have different expectation regarding the goals and outcomes of the course. Some members are more ambitious and motivated than others, which shows in higher levels of commitment. Cultural problems, such as language skills and behavior specific to cultures also influence the process. Often, these differences are realized quite late in the process, which often leads to problems.

Therefore, there is need to design means for tuning in, to be able to understand others' backgrounds and to set up common goals and values. Team members' expectations and motivation should be clarified from the beginning. All members have different point-of-views, but understanding them and creating team specific objectives is critical for the success of the collaboration. Currently, it seems that teams are lacking a proper methodology for doing so. Hence, there is an opportunity for designing ways to create better understanding of the teams' skills and resources as well as common motivators, such as goals and values. Carefully planned methods should be provided to enable teams to tune in and offer a possibility to improve team dynamics throughout the project.

Figure 20: Summary of design drivers

3.5.2 Teamwork protocols

Create structured knowledge sharing protocols for teams to enable efficient creation of a shared understanding of processes and progress.

Teams need to be able to create a shared understanding of their process and progress. According to my research, structuring, sharing, and managing knowledge to reach a common understanding is one of the hardest tasks to do remotely. Concerns created by "not being on the same page" caused stress for most teams in some part of their projects. Moreover, often these problems appear to be quite surprising. All information is not documented well and it quickly becomes scattered, which leads to frustrations and misunderstandings. Understanding of what to share, how, and when are problems teams do not necessarily know how to repair. Teams should also be more visual in their communication to enable efficient exploration of documents and data. It was mentioned several times that often communication was too verbal and for example purely text-based documents were easy to overlook.

Furthermore, team members are concerned about the level of their understanding. It is hard to keep track on all the information created and make sure everyone is equally updated. One clear finding was that teams are lacking proper rules and methodology to support the creation of a shared understanding. Hence, there is a need to create structure for the way information is processed and shared. Reaching a common understanding of all the work that is done during the project and where the team is heading will foster honest and productive collaboration.

3.5.3 Structured decision-making

Create illustrative ways to capture ideas and insights to enable in-depth perception of concepts, and provide structured methods for decision-making processes.

My research shows that one of the hardest phases in distributed collaboration is communication of ideas. When teams move into prototyping phases, positive energy increases. Still, the way results and insights are communicated could be improved significantly in both phases. Teams need to be able to capture essential information in an understandable way, keeping in mind important details as well as the context. Teams also need to ensure ideas do not get lost. Based on the interviews, most teams did not have strategy or a predetermined way of recording and sharing concepts, which showed in insufficient understanding of others' input. Also, teams are surprisingly verbal when communicating findings, although some teams discovered visualizations and videos to be extremely useful. Structured, but creative ways of sharing insights could be encouraged to be able to create good culture for capturing essential information as well as to assessing it.

As mentioned, misunderstandings related to specific phases are often a cause of inadequate communication. The problem is twofold; the way ideas are documented and shared as well as how the information is processed on the other side. As a result teams discovered that this leads to the problem that decisions are extremely hard to reach. Another factor influencing this is the lack of methodology for deciding. Moreover, most interviewees revealed decision-making problems that lead to conflicts. Often, it was a results of two (or more) competing ideas created in different countries. Teams should reject certain mindsets, such as "being the owner" of the idea and therefore, not being able to understand others' perspectives or other ideas equally. The way ideas are communicated and understood has an impact as well. If ideas are not seen as equal in terms of the way they are shared and perceived, it will easily lead to a competitive situation. Considering all factors mentioned above, opportunities are seen in creating methods for equal, creative, and structured processes for sharing ideas and insights as well as making decisions.

3.5.4 Notes regarding further steps

Based on my research, bringing structure to certain processes as well as team protocols would be valuable and helpful for the teams. However, having too much structure can also lead to problems. Teams need to have a sense of freedom; to be able to select the tools and methods they see useful. Therefore, when moving to next phase it is important to keep in mind the need for balance between structured processes and flexibility. Tools or methods created cannot be forced or too serious. For example brainstorming methods are often humorous and playful in a way or another, but also extremely useful for the specific purpose. Therefore, it is important to consider these factors when developing potential solutions.

04 DESIGN DEVELOPMENT

04 DESIGN DEVELOPMENT

"What I cannot build, I cannot understand"

-Richard Feynman

The aim of this section is to give an overview of the design development process and its different phases. Starting from initial idea generation and inspirational benchmarking to developing a final concept that was tested with ME310 students. In the end, suggestions for future development will be described.

4.1 RE-FRAMING THE SCOPE

After creating three design drivers I started to generate ideas, which would answer to the problems presented by each driver (Figure 21). Quickly, it became clear that all three drivers are so large in scope that in order to develop a feasible concept I should choose one to develop further. However, all three of them also have overlapping features. Therefore, choosing one as primary target, without completely ignoring the important aspects presented in the other drivers, felt like a good decision.

The first one, "tuning in and keeping track", seemed to be a potential direction at first. However, it may not be the most critical in the context of this study since all the ME310 students meet in the beginning of their projects and are given support in the form of lectures, workshops and working methods. Nonetheless, I saw several potential solutions, such as team building exercises and worksheets for tuning in and enabling teams to kick-off their projects in a more effective way. The second driver, "creating a shared understanding", is definitely a critical problem as also noted already in the theory section of this thesis. This challenge would also require a thorough understanding of the problems causing misunderstandings and communication difficulties. Based

▼ *Figure 21: A few ideas of initial brainstorming*

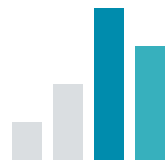
Criteria Sheet

Criteria "Pool"

Workshop guide for decision making

"Idea Tinder"

Idea Template



Metrics & Measurements

Briefing Package

Checklist for Concept Description

Decision-making Game

Team Protocols

Values Sheet

Availability Sheet

on the initial idea generation, this is also the most difficult one to answer. There is vast number of factors influencing the creation of mutual understanding that developing potential solutions that would aid the team throughout the project, is very demanding. Also, this driver is not as concrete as the other two. Therefore, focusing on a specific phase instead of the whole process seemed like a better option in terms of keeping the work focused.

After considering the options, I chose to proceed with the third driver, which is related to the design process and decision-making, for a number of reasons. First, based on my personal experiences as a student as well as a coach, there is a great need to seek answers to this problem. Second, there is little or no research done on the convergence phase of a design team, where team members are equal, multidisciplinary, and work in distributed settings. Even though this problem is not easy to solve and the context is mostly an unknown territory, there is great potential from my personal designer's point-of-view. Therefore, I formulated a question to guide the next steps:

How to develop a structured method to assist a design team to communicate concepts and make decisions as a team?

Validating assumptions by observing

As mentioned previously, during this project I had the opportunity to observe current students of ME310 at Aalto University Design Factory. Although my observations were not completely systematic but followed up on a daily basis, it was useful for validating my choice of direction. During the time of this study I have witnessed several challenges with teams due to the conflicting point-of-views stemming from team members working in different countries. In some cases the disagreements and communication challenges have resulted with problems in team dynamics. Not having a coherent direction and vision as a team easily leads to frustration.

In some cases a team starts to debate without having enough evidence to support their arguments. For example, prototypes or concepts are not properly built or tested to demonstrate their potential. Or in some cases, the proposed solution may be too vague, which easily leads to inadequate understanding of the idea. Decision-making also causes frustration and often teams are not prepared for this, which might lead to avoiding the whole process of making decisions. One very important point to acknowledge is that decision-making is a time-consuming process and teams should reserve

time for it. Also, the process is not commonly predefined or structured as there are not many methods or means that could be utilized directly in this process. This might lead to the problem that teams are not on the same page on how to decide or how to go through the process of evaluating. Often, as noted in the analysis, decision-making is based on long unstructured discussions and efforts of trying to convince the other team members of one's own idea, which often leads to a competitive situation. Being able to give all the proposed ideas an equal opportunity of being accepted for further development seems to be demanding for most teams.

In my opinion, when it comes to important decisions, effective decision-making should not happen quickly, automatically, or without significant effort. Design teams should acknowledge this and reserve time for making decisions for an example regarding their team direction, vision, next steps or the final outcome. Creating order to this process, which is often chaotic, could yield very positive results.

4.2 REMINDER OF THE USER NEEDS AND REQUIREMENTS

As an input to the concept development phase it is important to review the requirements and the discovered needs specific to the context. Students adopt new ways of working quickly, but if a method or a tool requires continuous effort in learning it will most likely be abandoned quickly. As an example, interview findings revealed teams abandoning communication tools that had too complex user interfaces. Therefore, there needs to be a low threshold for actively starting to use any new tool. Motivation also fades away quickly if the solution is not intuitive and user friendly. However, due to different backgrounds and disciplines, team members often have contradictory preferences regarding functions needed and what is considered aesthetically attractive. Pleasing everyone may not be possible, but simplicity is one key factor to keep in mind. Building on that, the solution should be extremely low cost to be adopted by the team without great investments. As mentioned already in the theoretical background, social and unplanned meetings are important for collaboration and team dynamics. Ad hoc communication should be encouraged as it has proven to bring the team members closer to each other. Therefore, the solution must be flexible and independent from time and place. It is also important to design the solution to be accessible and quick

to use. As noted in the analysis, energy levels and mood might decrease quickly if a method, workshop, or a meeting takes too long.

Since the context is distributed working, it is important to keep in mind the ability to structure and transfer knowledge easily from one location to another. In this context, organizing knowledge might become chaotic quickly because of the information overflow that often surprises the teams. Therefore, the solution must bring structure to the ways of working. Last, the developed method must support the existing course structure, practices, and ways of working to be adopted by the teaching and student teams in different countries.

4.3 INSPIRATIONAL BENCHMARKING

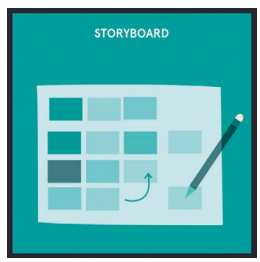
4.3.1 Design process support and methods

There are several process frameworks and methods, such as the ones developed by There are several process frameworks and methods available publicly, such as the ones developed by IDEO and Design Council, that are commonly known in design and product development environments, but most of them are not designed for distributed teamwork. In software development, agile frameworks, such as Scrum (Scrum Guides 2015) have been widely used to facilitate and manage complex software development projects. The key is to provide just enough structure to manage the team and the complexity of the project without creating too many rules or restrictions to limit creativity and freedom of choice. Clear roles and responsibilities also support the process. Another successful framework, the Lean methodology (The Lean Startup 2015), is similarly trying to create some order to ambiguous teamwork. In the heart of this methodology is an iterative build-measure-learn loop that was originally built for entrepreneurs to create successful startups. Moreover, early user testing and validation is an essential part of this process.

There are also more detailed tools available, for instance IDEO has developed several methods, such as the Design Kit (Design Kit 2015), which is a collection of techniques to facilitate the design process and its different phases. The collection includes tens of methods for all stages starting from gathering user needs to creating a detailed plan for implementation. Some of them are widely known and also used in ME310. Overall, the

Design Kit is a comprehensive set of tools that offers method options for facilitating different types of design teams and projects. The value of these methods comes from simplicity of execution and the visual step-by-step guidelines to follow. Often ME310 teams use these types of tools and methods independently as guidelines for their teamwork. These tools are, however, not context specific. They offer a great deal of freedom, which may lead to the problem that outcomes are not what was expected as the guidelines were not followed in detail all the way through. Moreover, these methods do not dig into detail, neither offer any example templates for exercises. Nonetheless, this set offers great inspiration for trying out different types of methods. Similarly, Design Council (2015b) also offers guidelines for different phases of the project, such as instructions for assessing ideas. Although being well formulated, these guidelines merely scratch the surface when it comes context specific work. To facilitate the process more effectively, it could help to anchor the guidelines more closely to the design process, creating more detailed instructions, introducing time pressure as well as adding some fun with gaming elements.process more effectively.

Figure 22: An example of a Design Kit method card and step-by-step instructions (Design Kit 2015)



Suggested Time
60 Minutes

Level of Difficulty
Easy

Materials Needed
Pens, paper

Participants
Design team

STEPS

01 With a partner, determine what it is you want to prototype. You don't have to Storyboard the entire offering. Use it to test even one component of your idea, like an interaction, or how a customer finds your product.

02 Spend no more than 30-45 minutes drawing how your ideas work. Use a series of comic book-style frames for your drawing. This will help you spotlight key moments and build a short narrative.

03 Don't get hung up on your drawing abilities. It's more important that it helps you fully think through your concept than create something that looks beautiful.

04 Once you're done, act out the Storyboard to your team for feedback.

4.3.2 Gaming approach

Design games are commonly used in participatory co-design sessions (Brandt et al. 2008). There is no ultimate definition for a design game, because the approach is flexible and depends on the context (Vaajakallio 2012). Vaajakallio (2012) studied design games

in the context of co-design and presents three qualities these participatory games have in common: “1) they provide a common design language, 2) they promote a creative and explorative attitude, 3) they facilitate the players in envisioning and enacting what could be” (p.100). Although design games are often used in early phases of a design project, a gaming approach might bring something to the table that is clearly missing, a sense of fun to the decision-making process.

Lego Serious Play, developed by the Lego Group, is an interesting benchmark linked to playfulness in participatory sessions. I think this is a fascinating approach that combines playfulness with serious topics of discussion (Lego.com 2015). In short, the method is about solving complex problems by building 3D-models of them using Lego bricks. The session is done with the help of a trained, certified, facilitator. This method is said to be effective when teams are dealing with ambiguous matters and wish to enhance their performance. The process is set to provide deeper understanding and to facilitate effective dialogue within the team by using physical metaphors which are made out of Legos. Interestingly, it is also said that the method helps teams to reach a mutual understanding and to make effective decisions. Clearly, the core is in shared physical representations of abstract concepts that stimulate creativity, provide a mutual language, and ensure sharing of tacit knowledge to gain deeper understanding of the topics discussed. The facilitator’s role seems to be crucial as they offer the rules and questions that formulate the basis for the sessions and ensure it progresses as planned.

In my opinion the gaming approach forms a good structure for a design session and allows participants to deeply focus on the topic through rules and provided game material. Moreover, games can engage users and format effective dialogue between

Figure 23: Lego Serious Play Starter Kit (Lego.com 2015)

participants (Brandt et al. 2008). Designing games, however, is not a simple task. As Brandt et al. (2008) explain, the level of difficulty cannot be too challenging nor too simple. The content, physical game pieces, and level of abstractness all affect on this. Although the gaming approach will not be in the core of this study nor the development process, it will serve as an inspiration for the next steps.

4.3.3 Methods of making decision

Commonly known decision-making methods are often analytical and suitable for measurable ideas only. These methods, such as Pugh Concept selection, have been widely used in engineering projects (Ulrich & Eppinger 2008 pp.117-120). The methods are usually based on matrices in which there is a set of predefined attributes, which are then valued by giving out scores. Each solution is evaluated using the same matrix and the overall score decides which option is the most suitable one. Similarly, Delft Design Guide (Boeijen et al. 2010) presents a variety of decision-making methods, such as "Harris profile", and "Weighted objectives", that fit to this category. This collection includes methods for assessing early ideas as well as evaluating further developed concepts. Still, commonalities in these methods are predefined attributes that are compared to proposed solutions.

When dealing with open-ended problems, in which answers are never wrong or right, these measures cannot be directly utilized as they are. In fact, often the success of a product development project can be evaluated only after entering the market. Still, as discovered in the interviews, teams wish for structured methods to ease the convergence process. Therefore, there are potential in these traditional methods, although they must be customized to fit the target users and context.

▲ ***Figure 24: Decision-making matrix***

4.4 CONCEPT CREATION

In an ideal world, in addition to passion, decision-making would be based on learnings and data; how the first prototypes came to life and what were the major insights from user testing. Reaching consensus would be easy due to perfect mutual understanding of all knowledge. Ideally, the rationale for each concept would be crystallized and the team would have a full understanding of all associated information. The decisions would be done based on testing results and user feedback, keeping in mind the team's core values and passion towards different ideas. The process would be productive, reflective, and done in mutual understanding.

4.4.1 Starting point and key features

Convergence Guide

The ideal scenario described above served as an inspiration for the concept development process. I had a gut feeling that the problems related to decision-making cannot be solved by one simple tool. Therefore, I decided to develop a Convergence Guide. In principle, the purpose of this guide is to work as a support in decision-making processes but it can also be used as a basis of a facilitated convergence workshop. The aim is to bring structure to the concept documentation and evaluation process as well as to create a shared understanding of the knowledge the team has in order to create a better basis for making effective decisions. The ideal use case would be to utilize the guide after a divergence phase in which designers have created multiple tangible solutions to the earlier defined problem (Design Council 2015a).

As Du et al. (2012) stated, without a mutual understanding critical information supporting design decisions and the reasoning that led to them might get lost. Based on this study and my personal experiences, this is a valid argument as teams often seem to argue about choices without having a full understanding of all concepts or the rationale to support their arguments are missing. Therefore, the main objectives of this guide is to enable teams to:

1) Agree on common values and criteria
2) Understand others' points-of-view
3) Reach a mutual understanding of the knowledge and concepts created
4) Make decisions as a team based on learnings and teams' own value criteria

The starting point was to develop a clear guideline with simple steps to guide the process. With the help of visual templates and worksheets the process would be tangible, which is needed to make the process interactive and productive. The overall process for this concept includes five steps.

Figure 25: The process for the Convergence Guide

1. Prepare

Making sure that concepts and prototypes are tested and the rationale behind them is clear. Reading instructions and understanding what is needed for the process of making decisions. Tuning in to the process.

2. Define

Defining and agreeing on a decision-making criteria as a team.

3. Synthesize

Summarizing key findings and features of concepts in a coherent manner to understand all ideas equally.

4. Evaluate

Evaluating concepts based on predefined criteria.

5. Decide (and reflect)

Comparing evaluations and reaching a decision as well as reflecting on the decision made.

Figure 26: What is needed for a convergence session

The process of this guide may not be new or revolutionary, however, it is tailored to fit to the framework of this study. All the research was conducted in the context of ME310 and therefore, the primary target users are ME310 students and teaching team members, although the solution can possibly be used in other similar contexts as well. The purpose of the guide is to offer clear guidelines, concrete steps as well as an explanation of the importance of each step. The following chapters will describe the details of the guide as well as showcase the progress realizing it. The final guide can be found from Appendix on page 136. Although the process described here may seem extensive, I think all the prescribed steps are important when trying to reach a mutual decision as a team. Decision cannot be made without understanding all the different concepts. Moreover, to be able to understand and evaluate the concepts they need to be tested and documented before converging in on a decision. Different point-of-views must be made explicit and the rationale for decisions should be clarified. Providing a good structure for productive discussions as well as reflecting on choices made is also necessary to ensure the decisions will be followed up.

Why a prototype?

The aim of this thesis was to create a concept that is not ready made product to be launched "on the market" but a prototype that demonstrates the potential of the idea. Moreover, before tackling the challenges of taking this idea into virtual worlds and global virtual teams, it makes sense to test and validate it first locally. The ME310 philosophy focuses on building prototypes early to assess the potential without wasting too much time in early idea development on implementing something that requires extensive time and effort, and which might end up failing in the end. Therefore, I chose to proceed with a physical guide format that offers a clear process structure as well as exercises to complete whole following the process. The reasoning for this relates to validation potential, as the overall aim was to develop a concept that can be tested quickly. If the solution shows potential, it can be developed further and transferred to virtual worlds more efficiently, without wasting time on features, which might not even work in the end. Next chapters will describe the development process in detail.

4.4.2 Criteria development

To form a solid basis for this guide I wanted to create evaluation criteria that could be used in the process. Although the purpose is that teams will come up with their own set of evaluation attributes they consider to be important when evaluating ideas, I saw

potential in offering examples that could be used as a basis for this process. Developing pre-defined criteria that could be used to assess concepts in multiple different contexts is impossible, but I felt that at least in the context of ME310 it is possible to offer a limited number of most common options. Based on my experience, at least part of evaluations should be made based on few key performance indicators. Firstly, what are the results of user testing? Secondly, how well is the concept answering to a real need or problem that the team has discovered during the process? Thirdly, how feasible it is to implement the idea and build a proof-of-concept prototype to demonstrate it's purpose and potential?

Personal passion towards the idea is also an important factor as it motivates the team members to do their best and beyond. Gut feelings and personal opinions should not be neglected, but as noticed in the interviews for this thesis, sometimes they may be distracting objective evaluation. Therefore, I think a mixture of both objective evaluation and passion should be combined to reach best results in the evaluation process.

Criteria survey

To validate my assumptions I made a small survey for current and former ME310 teaching team members including one professor. There was only simple question to answer: Which four criteria should be considered when evaluating concepts and making decisions in an ME310 project? All in all, I had nine participants answering to

CRITERIA	Mentioned by (participants)
Does it answer a problem and/or need	6
Is it feasible	6
Passion	5
Gut feeling / Instinct	2
Results of user testing & Learnings	5
Innovativeness / Novelty / Impact	6
Company needs	1
Scalability	1
Market potential	1
Showability	1

Figure 27: Results of criteria survey summarized

this survey. A summary of the answers can be seen in figure x. The results correlated with my preliminary thoughts and based on the results, the top four criteria were decided.

> *"Decision-making should be based on learnings, depth of research and testing, and a vision." (former professor of ME310)*

What became clear from this survey was also the way decisions should not be made. Many of the participants mentioned that teams should never make compromises or just vote. Listening and getting input from everyone is important but compromise can also lead to a compromised outcome. Having a clear vision and passion towards the idea is essential for feeling motivated to implement the chosen idea, as noted in the quotes from the survey. However, it is rare that all members are passionate towards one single idea when making decisions.

> *"There is the possibility of infecting others with your passion."*

> *"Decision-making should not be based on voting, justice (we did your idea before, no let's do ours), or letting the strongest person decide."*

> *"The selected idea has to be inspiring and a bit crazy."*

It is also important to keep in mind that the project brief given might determine some of the evaluation criteria. Therefore, the evaluation method should have the flexibility to adjust the criteria when needed. Based on through analysis of different points-of-view, I decided to have four predetermined criteria that can be used in the process, but also have the possibility to add up to four additional criteria, that will be chosen by the team.

All in all, the most valuable criteria affecting the design decisions seem to be fairly clear for the teaching team members, but these should also be made explicit to the students. Even though the results from this survey will be utilized in the development of the guide, the purpose is not to force student teams to use this set of attributes. In my opinion, it is important to offer flexibility and options but also to provide a solid starting point for productive, professional discussions. It is easier to start from somewhere instead of a blank paper. Therefore, I chose to proceed with the following suggested criteria:

1. User experience - How well does the solution answer to a discovered problem or need?
2. Feedback - How positive or potential are the results of testing?
3. Feasibility - How well are you able to implement the solution?
4. Uniqueness - How novel is the concept? How big is the impact?

The last one gives an option of choosing either of the two criteria. It was hard to distinguish between these two and therefore, I decided to give the choice to the teams.

4.4.3 Tuning in

Before starting the process of decision-making, it is extremely important to understand what others value or believe to be important when making decisions. In this Convergence Guide, the first step in doing this is to understand the teams' point-of-view regarding the process and what are their personal goals regarding the outcome. Therefore, I decided to include a short "tune in-activity" in the beginning of the process. This is a quick exercise in which all team members can participate in a meaningful way, by sharing personal values and passions. The team will use this exercise as basis for the next step; formulating their own decision-making criteria.

The core of this exercise is to talk about personal passions and values regarding a successful outcome. The aim is make team members understand what each individual consider important. The instructions in the guide are as follows:

1. Use five minutes to write down three most prominent values or passions you have (using post-its). What do you consider being important when evaluating ideas and making decisions? What are you passionate about in a project? What makes projects successful?

2. The second step is sharing these values with the whole team. Collect the post-its and read all of them aloud. Discuss. Can you find similarities? Passions that complement each other?

4.4.4 Evaluation criteria

After the tuning in, the next step is to agree on criteria that will form the basis for making decisions. My hypothesis is that mutually agreed criteria help to evaluate ideas and to see the full potential of the proposed solutions. For this step, I included the criteria developed earlier in the process. The aim is also to utilize the values created in the tuning exercise to make sure team members are also passionate about the chosen criteria. A worksheet, called "Criteria Sheet" is presented to enable placing the chosen criteria on a visual map.

The steps in this task include:

1. Discussing on evaluation criteria. The predefined criteria are presented to start the conversation.

2. Depending on the context of the project, additional attributes might be needed. Students are given the option of choosing maximum of four additional attributes.

3. Everyone should agree on the set of criteria before moving on to the next steps.

4.4.5 A template for synthesizing ideas

In order to assess concepts in a structured way, they have to be communicated equally. To make sure teams document their concepts in a proper manner there needs to be structured, pre-determined, guidelines on how to do it. Therefore, I decided to create a template that ensures the most important features have been documented carefully in a summarized form to avoid having too much knowledge to process. This means that documenting has to be kept short and to the point, but nonetheless, cover all key aspects of the concepts to assure as complete understanding as possible. As mentioned in the analysis, scattered information is a major problem. Therefore, having a solid structure for collecting and organizing the different concepts is needed. My previous experiences and data emerged from the interviews were combined to form the basis for this template.

> *"It was definitely not easy to communicate ideas and concepts to other countries. One thing I learned from ME310 is to try to build a prototype because it's a lot easier to understand it."*

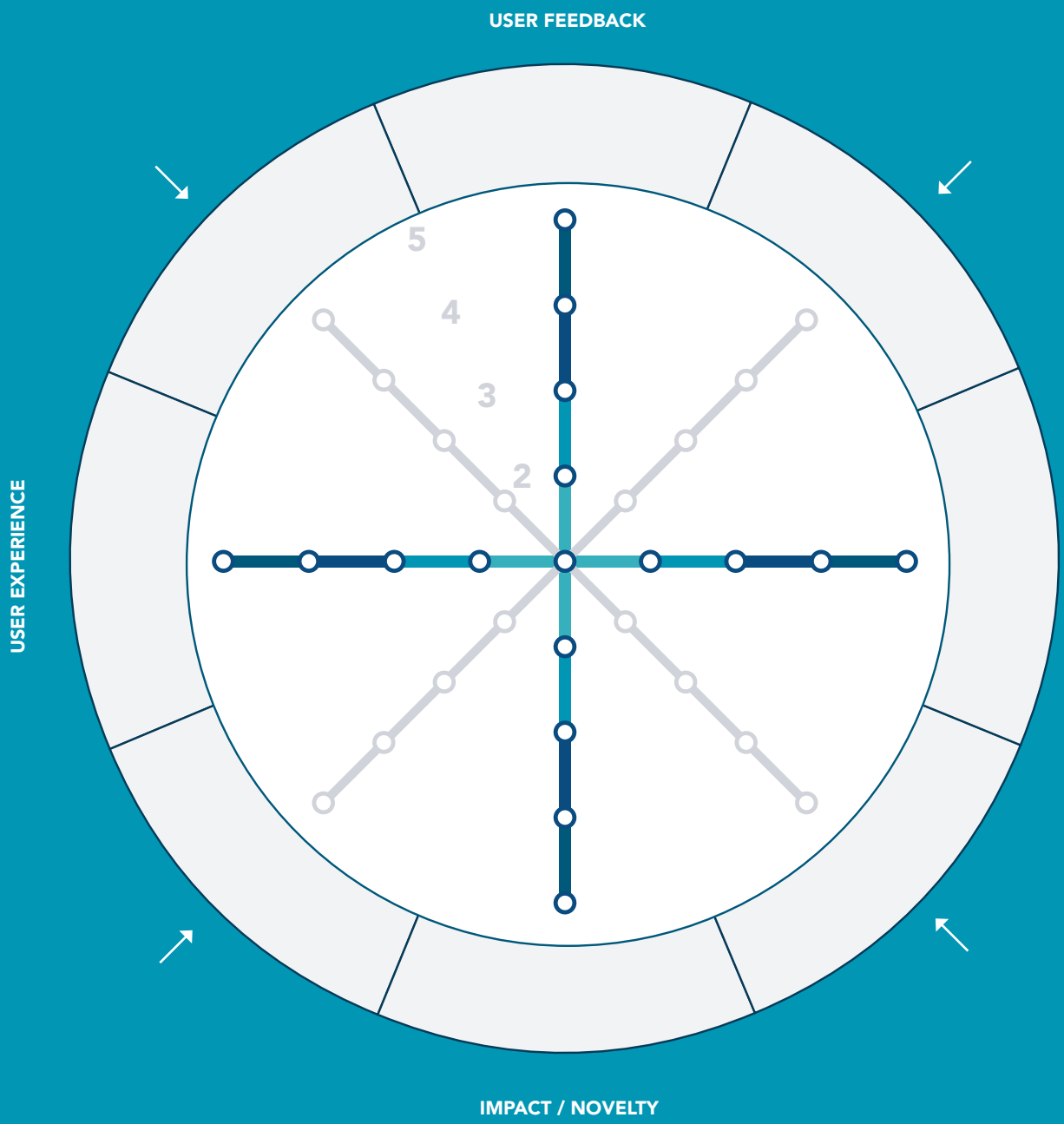
Figure 28: Criteria Sheet

30min

CRITERIA SHEET

DECIDE VALUES AND CRITERIA

1. *As a team, agree on criteria and place them on the image. Use maximum of eight attributes.*



Next step: Synthesize

What exactly needs to be communicated?

The first important aspect of documenting is naming the concept. Coming up with an inspiring and distinctive, as well as recognizable name is important. At its best, a good name embodies the purpose of the concept and gives it character in a clever way. The second and possibly the most important factor is to demonstrate the idea. As mentioned before, "Show rather than tell" is a motto used in the course. A description of an idea can be understood in multiple different ways but showing it in action brings understanding to another level. As discussed in theoretical background, shared objects are important in terms of creating a shared understanding, although they can be seen differently depending on the recipient context and culture. These artifacts act as a bridge building common understanding. Whether it is a tangible object or rapid prototype of a software program, teams need to be able to demonstrate the functionalities of a concept to reach common understanding of the capabilities and possibilities. There are lots of different ways to prototype, starting from acting out a scenario to building a fully functioning system. Nevertheless, showing the functionalities in a concrete way has proved to be the best way to make all team members understand the idea as comprehensive as possible. In distributed processes videos have proven to be the most effective ways of communicating the essence of a prototype. Therefore, there could be a requirement of recording short video clips of the concept when moving into virtual worlds.

To communicate the rationale of a concept, there are points to keep in mind. Firstly, a short description, that explains the core of the concept quickly, should be written. If this seems a difficult task, the idea for the concept may not be clear enough. Secondly, the core rationale of the concept should be easily understood. Therefore, the problem the concept aims to solve must be made explicit. Recognizing the target user and the needs specific to this user is essential. Designing for everyone is similar to designing for nobody.

Thirdly, test results and user feedback and key insights should be communicated to show that the concept is properly tested with real users. The results of testing are crucial: they either validate the concept and assumptions or prove that the idea, as it is, will not work. Since there are no definite metrics to measure the possible success of an idea, teams need to rely on user feedback. Moreover, this part ensures that all ideas are tested with real users to make allow comparability.

Figure 29:
Concept Template

15min/Idea

CONCEPT TEMPLATE

MAKE THE CONCEPT UNDERSTANDABLE

1. *Name of the concept*

2. *Demonstrate the idea - Show don't tell*

3. *Describe the concept in one sentence*

4. *What is the problem this concept aims to solve in one sentemce? Why is that a problem?*

5. *Who is the target user? What is the discovered user need?*

6. *What are the top 3 key insights of user testing?*

1.

2.

3.

Next step: Vision Statement

Vision Statement

The second part of synthesizing is to come up with a short vision statement. This task ensures that team members think and verbalise the potential of each concept in a positive way. Before evaluation and decision it is important to think about the full future potential of the concept and be able to relate to it even though it may not be one's favorite solution. Furthermore, the summarized points presented in the concept template may not be adequate for thorough and complete understanding. For example, the first iteration of the idea prototype may have failed, and therefore, it is critical also to think about potential changes that could make the idea better.

1. Have a look at the personal values created in the beginning and reflect them with each concept. How can you make each concept better with the help of your team members' passions? Make a short, positive, vision statement for each concept: how will this concept change the world? Why should we choose to develop this further?

2. Read your vision statements out loud and put them next to the concepts templates.

4.4.6 Evaluation - A visual way of demonstrating the potential

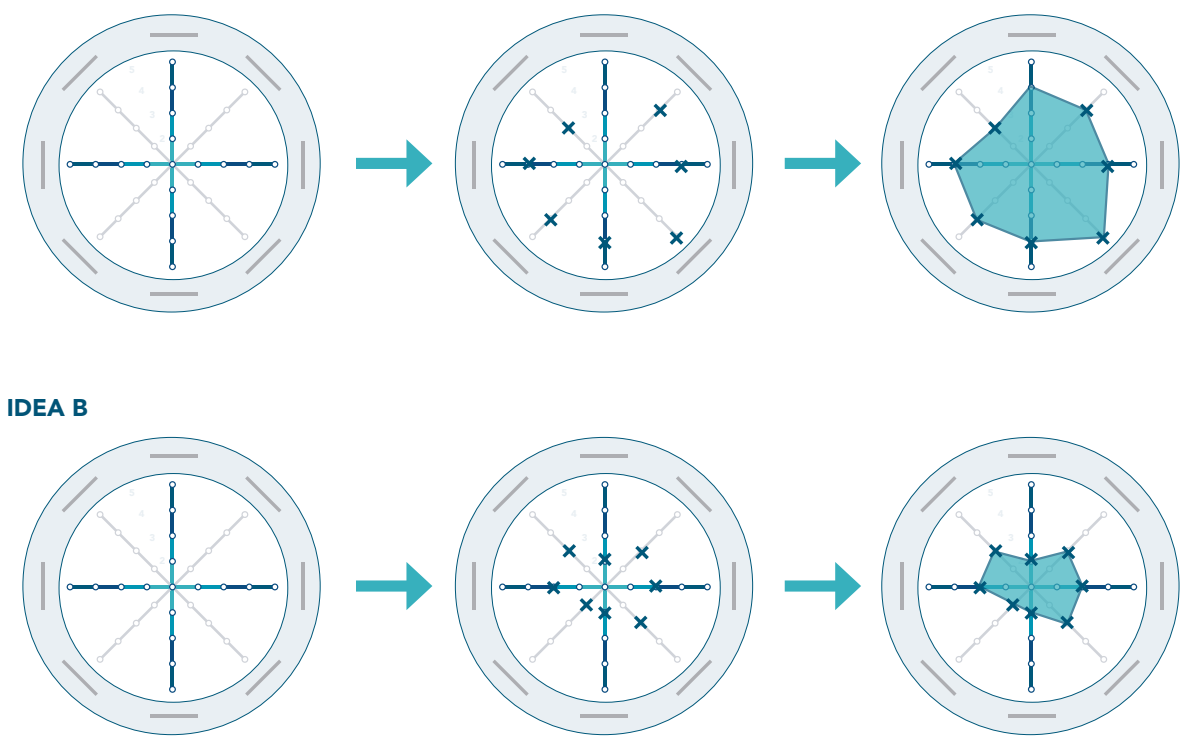
The next step after creating a shared understanding of concepts and the evaluations criteria is to do the evaluation. The rational for the evaluation sheet is simple; evaluating ideas based on criteria that the team defined in previous step in a visual way. For this context, I chose to use a "Star-diagram" type of way for evaluation. It allows the teams to rate the idea in relation to each attribute visually. The process for evaluation goes as follows (Figure 31).

1. First a team evaluates the idea in relation to each criteria, on a scale 0-5. After giving out scores by putting marks on the image, dots will be connected. In general, the larger the area the better the results of evaluation will be. The purpose is to instantly see the potential of the idea in a visual way. The aim is to also to try to be objective and discuss about the scores with the whole team.

2. After evaluation it is time to compare the concepts and move to the final step.

Figure 30:
Vision Statement

Figure 31:
Evaluation steps



4.4.7 Reaching a decision

Last step is to make the decision to reach consensus as a team. A good decision is based on solid learnings and a clear rationale. There also needs to be passion and motivation towards the best solution to make it happen. Therefore, the team needs to compare the results and discuss about alternative solutions in a productive manner. Each team member has to have the opportunity to provide input and opinions. All team members should discuss alternatives until they agree on a solution by using well constructed, objective arguments based on all information shared. The evaluation sheets should serve as a basis for this process, but should not be the only factor influencing the decision.

As presented in the guide, the steps go as follows:

1. Compare the visual criteria evaluations. Which ideas have the most promising scores? Are there similar ideas? Combine ideas if necessary, but do not force it. Choose maximum top 3 concepts.

2. Discuss and agree on the most viable option in terms of evaluation scores, passions and your vision.

3. Reflect on the decision made. Are you happy with the result as a team?

4. Take your vision for the chosen concept and make an action plan how to make it real! Come up with a strong vision as a team.

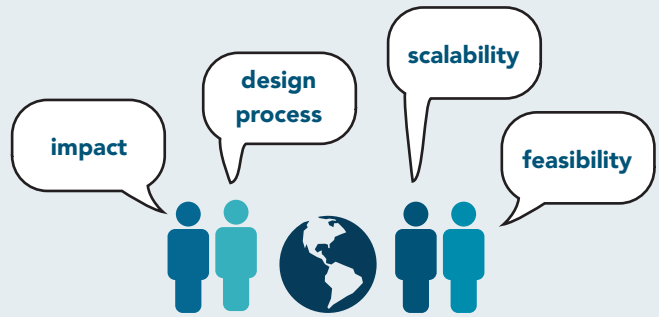
It is extremely important to consider all steps presented in this guide before reaching the final conclusion. A decision can be purely based on evaluation, but it is better to ensure all team members can also be passionate about the idea in order to get everyone working effectively for the shared, desired outcome. Therefore, reflection is crucial as well as ensuring that everyone “can have a say” in this process. Decision reflection also provides a solid basis for the team for next steps: formulating a common vision, defining an action plan how to proceed, and dividing roles and tasks to make it happen.

Figure 32:
The journey

1.

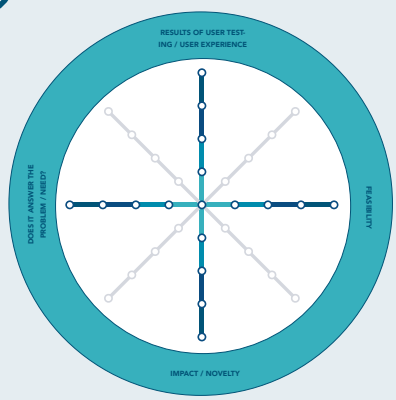
Before making decisions, ideas need to be tangible, tested, and carefully documented.

2.



Next, to understand others' point-f-views it is important to talk about personal passions within the team.

3.



1. xxx
2. xxx
3. xxx
4. xxx
5. ?
6. ?
7. ?
8. ?

The next step is to define the decision making criteria everyone can agree on.

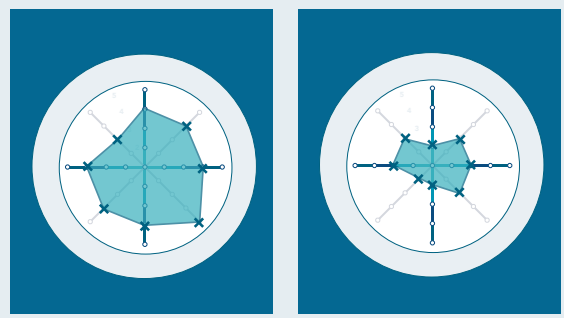
4.

Each concept should be summarized including: rationale, demonstration, and testing results

5.

Next, positive vision statements are made to consider the potential of concepts.

6.



Finally, decisions should be made based on results of evaluation as well as passion.

4.5 OVERVIEW OF DESIGN CONCEPT

To conclude, the Convergence Guide includes three worksheets, two smaller exercises, and detailed instructions for each step of the process (see Figure 34). In the beginning of the guide, the guide development process and background is explained shortly to provide clear reasoning on why this guide came to life. Furthermore, the schedule and time estimations for each step are given as a suggestions for reserving time for convergence workshops. Also, workshop instructions are presented in the form of "What is needed".

Using the guide

Personally I see this guide being used as a basis for the convergence process in global distributed design collaboration, whether it is a workshop or a process done completely in virtual environment. The instructions should provide enough information for each step to be able to use the guide without personal help, although in the case of a workshop, an outside facilitator is needed to guide the process. The worksheets are designed to be visually simple and intuitive to follow the steps easily. To summarize the process, Figure 32 on previous page explains the overall user journey.

Figure 33: Convergence Guide

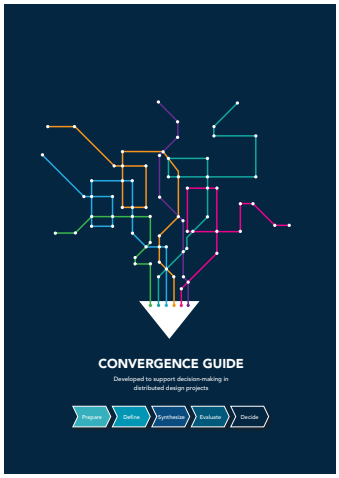
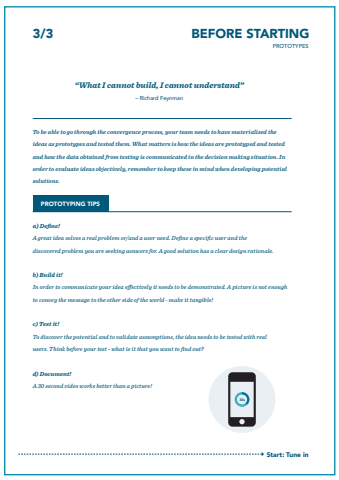
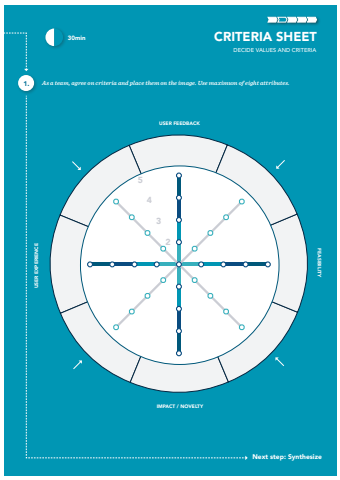
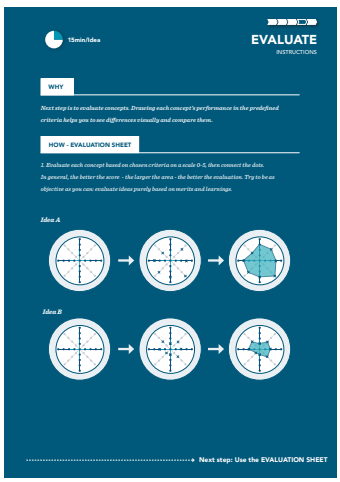
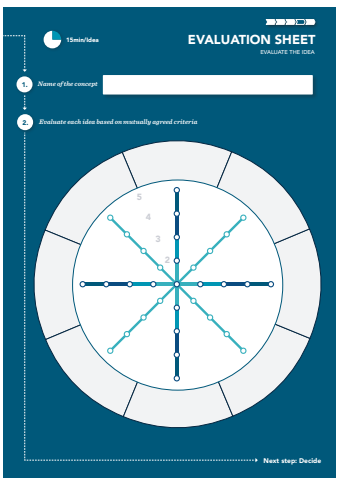


Figure 34: Preview of all pages in Convergence Guide









4.6 TESTING AND VALIDATION

A method like this can be hard to evaluate before actual use of several test groups. Nonetheless, in the beginning of the project I set myself a goal of testing the solution with students in a way or another, to be able to validate the different features and the process for this method. If the solution had been built in virtual context, it would have required more time and effort to create as well as several iterations to make it work, which was not possible within the time frame of this study. However, the research and development so far opens up interesting opportunities for future development, which will be shortly discussed in chapter 4.7. Despite the fact that developing a finalized version of a virtual tool was not an option, I wanted to test the process. Therefore, the next chapters present the test and validation process and document key findings from testing.

4.6.1 Feedback from teaching assistants

In order to get preliminary feedback before testing the process in real decision making situation with students I showed a draft of the guide to three current teaching instructors of ME310. The guide was printed out and given to the participants with a feedback sheet including following questions.

1) What are your first impressions of this guide?
2) In what type of a situation could this guide be used?
3) What parts you think could work?
4) How would you improve it?
5) Any other comments

Overall, the feedback was positive and encouraging, and there were also much needed improvement suggestions. Interestingly, all participants considered this guide as a facilitation kit for a decision-making workshop.

> *"The things that I consider being really important are: 1. Understanding all concepts 2. Understanding personal opinions and why people feel so strongly about some ideas."*

> *"I would use this for supporting struggling student teams. This would have been perfect for our intensive weekend with the students."*

"Good, well structured guidelines for a design team. Slight mismatch between the title and the content, the process seems wider than I expected."

"I can understand the rationale behind all the steps clearly."

"Concept template is a great idea."

The most fundamental improvement suggestions considered the order of the process steps. Depending on the team's situation there might be a need to modify the structure. For example if a team has documented their learnings in a proper manner already before the workshop, there might not be a need to repeat this step.

"All parts could work. Only the building part can be troublesome if nothing is done yet or then it should be clear that proper testing would be done before."

"All parts could work, although there could be a bit more freedom for teams to choose which steps are needed the most."

"I wish there were printing instructions."

"The preparation and requirements could be made more explicit."

Additionally, some parts of the feedback included quite detailed comments, which were mostly related to wording and details of graphics. All the feedback was considered carefully in the development of the final version before testing with students.

▲ ***Figure 35 - Preliminary feedback***

4.6.2 Convergence workshop with ME310 students

Fortunately, I had the opportunity to test my concept guide with a student team who was in a phase of their project that was perfect for testing. This team, which consisted of four students from Finland and four from the US, as well as multiple different cultures and disciplines, was on the verge of converging to future direction for their project. Before the workshop they had two potential concepts to develop further. Both country based subteams had worked on the concepts in their own countries, but at the time of this workshop, the whole team was physically in the same place, in Finland. The aim of the workshop was simple; to help the team to converge and to decide on the final direction of the project.

Description of the process

The workshop structure that I facilitated with this team was based on the convergence guide. I prepared slides using the instructions in the guide, printed out worksheets, and provided needed supplies as suggested in the guide. Before the workshop, I asked the team to bring prototypes and other potentially relevant material to the workshop. Based on the team's debrief of their project status, they had already carefully updated each other on what has happened so far in each country in the project. This was a fruitful starting point, as the team assured being on the same page with what has been created.

The team consisted of eight students in total, so I decided to divide the team into two subgroups in the workshop to make sure everyone can have a chance to share their view on opinions when completing the worksheets and exercises. To balance different backgrounds and disciplines, the subgroups consisted of two team members from each university. After completing the exercises, the results were always presented to the entire team to see if the other group had contradictory opinions. Each steps was concluded after agreeing on the results together as a whole team.

Tuning in and deciding on the criteria

In the beginning of the workshop I asked the students to individually write down three values or passions they consider important in terms of the success of a project or a satisfying outcome. The team members created passions, such as "it must satisfy a user need" and "distributed and equal group ownership", which demonstrated team member's points-of-view comprehensively. Overall, team members had relatively similar values to each other, which in my opinion, positively influences the dynamics

of the team.

The predefined criteria, given in the guide, were beneficial to providing a starting point for discussion. One subgroup decided to use all predefined criteria and add three more. The other subgroup modified the predefined criteria as well as came up with their own. After working on the two subgroups, the whole team had a discussion of the proposed evaluation attributes. Both proposals were merged supported by productive discussions and at the end the team was able to agree on six criteria.

- Technical feasibility – How well are we able to implement the final prototype
- Technical novelty of the solution
- Team satisfaction
- How well does the solution satisfy a user need?
- Design process – how logical is the chain of though in terms of learnings, and is there enough rational evidence to support the concept
- User experience and the "wow-factor" of the solution

All in all, the chosen criteria reflected on the values created in the beginning of the workshop as well as formed a good evaluation ground for this specific project.

Figure 36: Team choosing criteria

Using the concept template and coming up with a vision statement

The next step was to go back to concepts and synthesize the essence of them using the Concept Template-worksheet. Overall, synthesizing the solutions took longer than expected even though the information had been shared already before the workshop. Capturing all the essential information into condensed form seemed to be a tedious task. Therefore, I consider the use of the concept template as an important exercise before starting to evaluate ideas. From a facilitator's perspective, showcasing the prototypes during the synthesizing exercise was also extremely useful. A proper demonstration of each concept should always be done before making any decisions.

In the guide as well as in the workshop structure, the exercise of creating vision statement was originally planned to be after the evaluation. However, during the workshop I decided to change the plan on the go. Therefore, the next step after synthesizing was to create a positive vision statement for both concepts. This helped the team members to consider both options in a positive light and to think of how to improve the concepts. The use of personal passions that were created in the beginning was highly encouraged. All in all, I think this exercise was useful, as in the next phase, as a result, the participants were able to think of the potential of both concepts in addition to the already existing and shared knowledge.

Evaluating based on criteria and reaching a decision

The last step before deciding was completing the evaluation sheets and comparing the results. Both subgroups evaluated one concept, and before deciding, the evaluations were approved by the whole team. In this case, the results were clear as the one of the concepts received significantly better evaluation. Regardless of that, I did not want the team to decide purely based on that, but use the evaluations as basis for productive discussion. At this point, the proceeding of the workshop was surprising. The team was able to reach a mutual decision quickly, with all team members standing 100% behind one solution. Although, both ideas had potential, the evaluation showed that the one concept had clearer user need, as well as better potential of solving a real problem. This was the deciding factor for this team and as can be seen in Figure 37, the chosen concept had significantly better evaluation scores in this segment. Every member of the team saw the potential in the other proposed solution as well, but solving a real problem was considered to be more important than making something that is potentially magnificent but does not necessarily solve a problem. This was clearly a reflection of the team's

common values as most of the team members stated that solving a problem or a real need, is one of the most important factors determining the success of the project end result.

Reflecting on results

In the last part, I wanted to make sure that all team members agree on the chosen direction and can also be passionate and motivated towards the solution. Reflection proved to be an important step, because everyone was able to share their thoughts and wishes regarding the next steps. It became evident that some people wanted to learn new skills, some were passionate about exploring the discovered needs even further, and some were excited about building and iterating specific features of the concept. Excitement was seen in combining all the capabilities and resources of the team members to work towards a unified vision.

▼ ***Figure 37: Comparing the two evaluation sheets***

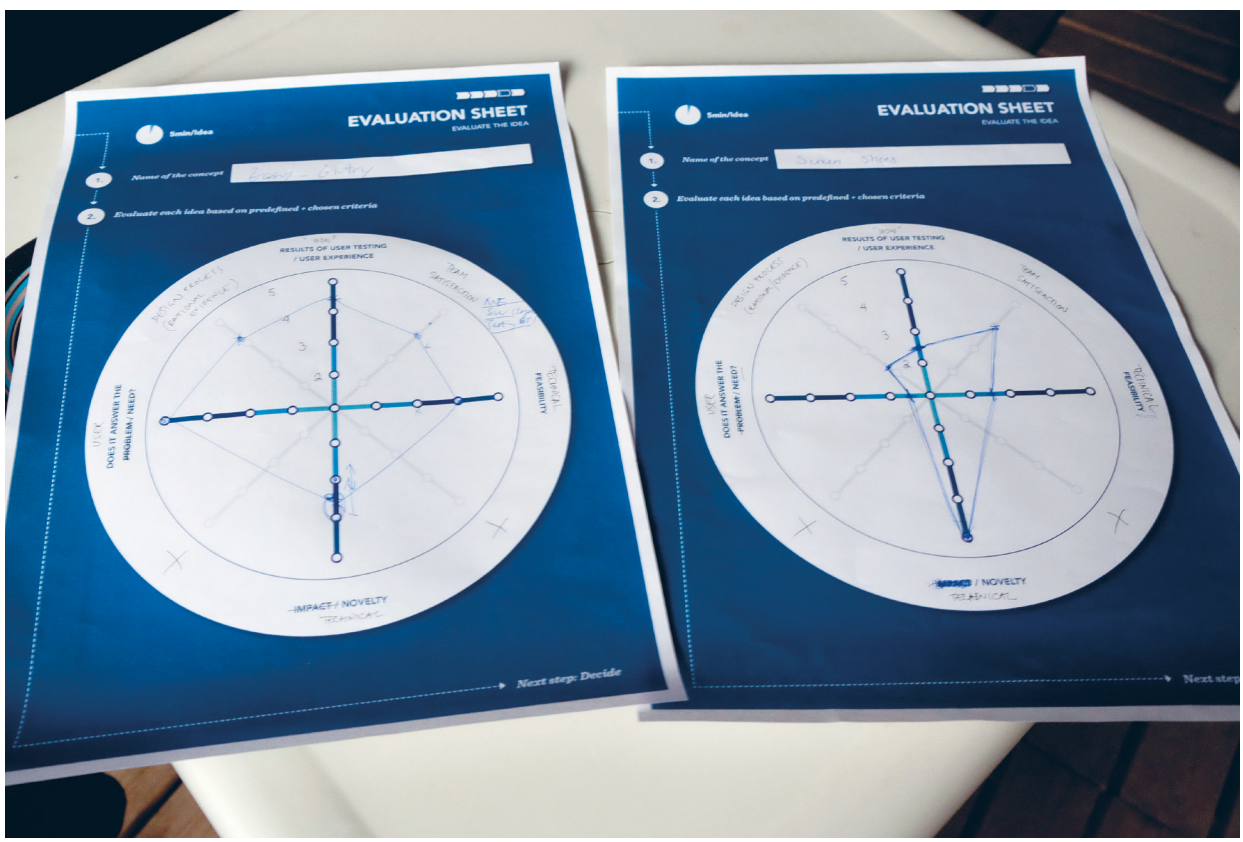


Figure 38,39,40,41: Images from the Convergence Workshop


EVALUATION SHEET
EVALUATE THE IDEA
Name of the concept
Screen Shoes
Evaluate each idea based on predefined + chosen criteria
DESIGN PROCESS (RATIONAL/EMPIRICAL)
RESULTS OF USER TESTING / USER EXPERIENCE
DOES IT ANSWER THE PROBLEM / NEED?
Next step: Decide


SCREEN SHOE
EASY-ENTRY, AUTOMATED CLOSURE SHOES
SOLVING
MUST
It should give an wow to other people
Name of the concept
Prototype shoes and tell

4.6.3 Summarizing the key findings

- Tune in-exercise, which consisted of sharing personal passions and values regarding a successful project, was effective in terms of starting the workshop in a positive tone.

- Developing common criteria was an essential success factor of the workshop. The observation that the values, that were created in the beginning, had a notable impact on the chosen criteria was surprising. Nevertheless, I consider this as an important finding as it implies that decision-making process should include both measured data and passion based criteria.

- Agreeing on evaluation criteria also enabled an improved evaluation process. Not only was it easier to evaluate and compare ideas, but also, most importantly, the team was also able to trust the evaluation of their team mates.

- Showcasing the actual prototypes was eye-opening from my personal point-of-view. Being able to touch something tangible truly brings the understanding to a another level.

- Evaluating the concepts in a visual manner made it easy to understand and compare the results.

- The overall structure of the guide seemed to work relatively well, although it needs fine-tuning and clearer instructions for previously mentioned parts.

-Clearly structured exercises and worksheets worked efficiently. The Criteria Sheet could be improved by giving more detailed instructions how to proceed. Another point is to explicitly state the freedom to also modify the predefined criteria based on team's needs.

- As a facilitator, my role was to make sure everyone has the opportunity to provide input equally. All in all, there were fruitful, productive discussions throughout the workshop – no conflict arguments, only rational, well-constructed arguments and good quality reflection from the team members. I believe this was one of the main factors influencing the success of the workshop. The team truly had a great attitude to listen to what each one had to say. I cannot identify for certain whether it was because of the good team dynamics or my facilitation efforts, but this part was definitely one of the

highlights of the workshop. Naturally, some members were talking more than others, but nevertheless, everyone had the opportunity to speak and others took time to listen carefully.

Areas for improvement

As expected, there were points recognized that could be improved for the next iteration. For example, time estimations for each task were too optimistic. Even though the team had only two concepts to work with, the completion of each task took longer than expected. The Criteria and Evaluation Sheets could have been more flexible in terms of encouraging modifications. All in all, going through all the exercises was a hard work load to handle in one workshop. The workshop lasted for three hours in total, which in my opinion would be the maximum length without long breaks. Nonetheless, I consider all steps being important when trying to reach a decision and therefore, I decided to keep the structure as it currently is. Depending on the team's situation, there could be a possibility to divide the session into two parts, if for example the team has several concepts to choose from.

A summary of results

Personally, I was amazed at how well the process went in the workshop. I cannot for certain say whether it was due to the abilities of this team, my input as the facilitator, or both. Hopefully, both had an impact on the final result. Most importantly, the team felt very satisfied with their decision in the end. The results and chosen direction was mutually agreed and excitement regarding the next steps was evident. To conclude, a quote from a student summarizes the overall feedback quite well:

> *"That was an eye-opening experience for us. We were impressed by how efficient and effective the workshop is. We will take this good experience back and suggest this kind of workshops to our teaching team as well."*

Naturally, this type of feedback warmed my heart and gave me the feeling that all the work done during this study was actually useful, meaningful, and there are great opportunities for further development. Naturally, once test group is not sufficient to validate the proposed solution, but due to time limitations and not being able to find other teams that would be on the verge of converging, I had to settle for one test group.

4.7 ENVISIONING THE FUTURE – HOW TO TRANSFER THE SYSTEM INTO DIGITAL WORLDS

As mentioned before, within the time frame of this study it was not possible to develop a fully functioning system that would work in virtual environment, nor was it the goal either. Therefore, the prototype guide developed as a part of this thesis was optimized for physical guidebook format distribution and use because it allowed to test it, to gain understandable feedback face-to-face and iterate rapidly. The overall feedback from students as well as from the teaching staff was very positive and encouraging, although further testing would be extremely useful. Nonetheless, testing was an important step regarding future development. For near future, as this guide and the methods it contains, is meant to facilitate product design teams collaborating remotely using technology, there are several modifications and improvements to make it work well in the digital world. Next, I will shortly describe the vision for future development, gradually moving from minor changes to a more bold future vision.

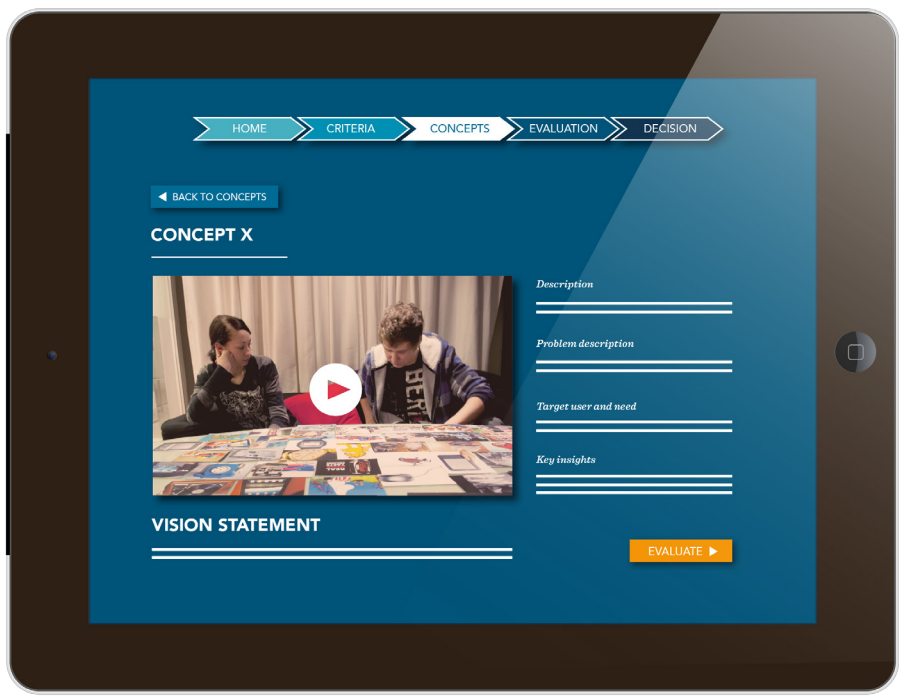
4.7.1 Step 1 – Online guide

The first step would be to transfer the guide, as it is at the moment, into online environment to enable teams from different places to download it and to use it simultaneously. The workshop format would still be valid, but the use of video conferencing would be necessary to complete all the actions in distributed settings. The most important part would be the use of videos; the prototypes and concepts should be documented in a way that all participants from different locations can formulate a comprehensive understanding of concepts presented. Moreover, objective facilitation could still be needed to keep the convergence conversations on track and to the point.

4.7.2 Step 2 – Convergence tool

The second step would be to develop an online tool that would facilitate the process with the help of technology (Figure 42). Possibilities of integrating the system as a part of existing tools should also be considered. In this step, simple changes would be required to adapt the process to online media. First of all, this tool should allow teams to document and collect their ideas and concepts into the same repository. One key finding in this study was the problem of scattered information. Therefore, it would be critical to have a platform where to synthesize all the concepts in an understandable way. The concept template could be used as a basis for this, although minor modifications are

Figure 42:
Convergence Tool



needed to make it function online. Again, the use of videos in explaining the prototypes would be extremely important to gain a deep understanding of the knowledge created. Possibility of grouping and categorizing the ideas would also be useful to be able to manage all the information that is created during the process. Simultaneously, ideas could be evaluated using teams' own predefined criteria. With the help of technology, I see potential in using sliders or other simple methods to evaluate each attribute separately (Figure 43). The program would then generate visual evaluations to make the comparison process as easy as possible.

To conclude, with the help of technology, the process could become more interactive. Teams would have the opportunity to add links and interactive media content if required. The tools should be available from any device, making it accessible regardless of time or place. All in all, with relatively simple modifications, the tool could function well in virtual environments. The only concern is following the process and the steps to reach a mutual decision, as it might be hard to accomplish online.

Figure 43: Evaluating a concept using a slider

4.7.3 Step 3 – Future possibilities

There would be interesting possibilities to use this tool for collaborative evaluation process for different kinds of content. The current online tools available for such, in for an example project management software, online design communities, massive open online courses (MOOCs) are very limited. Usually they consist of verbal commenting, Thumb up–button and in the most advanced cases simple, one dimensional rating with numbers or stars. More elaborate and comprehensive tools supporting team-based collaboration might improve teams work efficiency and quality in many specific use cases. The possibilities to realize this would be manifold: 1. Having the evaluation tool as its own platform where you collect material to be evaluated 2. Embedding the tool as part of already available software and platforms 3. Making the tool content and software independent, for an example Internet browser plugin. Each of these would be interesting options, each one with their own advantages, disadvantages, and challenges in realization.

To conclude, although there are several possibilities for future implications, it is vital to recognize the fact that this process and guide is most likely at its most effective when doing workshops with the help of an outside facilitator. Overall, the process of making decisions is time-consuming and demanding. Having a person in charge of a decision-making session by giving out instructions and time limitations, letting the teams focus on the essential matters, makes the process easier. On the other hand, if the team would for example continuously use an online tool mentioned in step 2 the process of deciding might not be as hard as it is now, because more work towards reaching a mutual understanding would be done throughout the project.

4.8 OUTSIDE FACTORS AFFECTING THE TEAMS' PERFORMANCE

To conclude this section, one fact that should be acknowledged when developing new methods for distributed collaboration in educational environments is the difference in teaching styles in different universities and how that impacts the teams' journey. Several participants brought this up during the interviews for this study. The problem of not being on the same page does not always come directly from the teams' own ways of working but different course criteria and schedules as well as the methods of teaching.

"I feel like both teams were sort of living their own lives – doing their own things... It was also because the teaching culture was different in both universities."

Based on the interviews in this thesis, most of the teams experienced problems caused by different requirements and schedules set by the varying course structures in different universities. Although the course follows the same process and basic principles in each university there are different levels of time commitment that are expected from the students. In some universities the students receive more than 50 ECTS by completing the course and in other universities ME310 is worth only 8 credits. This sets different starting points for students regarding motivation and commitment. Depending on the university, time used for the course may not be corresponding to credits received.

"I would talk about the motivation and goals in the beginning. We had different expectations and the process was not followed that well in our university, which really surprised me."

The interview participants felt that the course staff should acknowledge the extra pressure and conflicts caused purely by the different requirements. Many of the interviewees stated that the teaching team should address these issues in the beginning of the project. Due to the hectic nature of the course these "outside factors" should not cause additional burden for the teams' communication and collaboration. The best case scenario would be to have equal standards for all students considering commitment, credits and requirements, no matter in which school they complete the course. Teaching culture should be synchronized in way that the methods and assignments would follow a similar format.

"Outside factors (different teaching methods) affected the group. For example the way the teaching team encouraged or motivated the team and what were the expectations."

As a result of these findings, if the convergence guide would be utilized in a course as a part of the teaching material, my most sincere wish would be to get the teaching teams on the same page. That way, students could actually benefit from this set of methods as well as other possible tools and guides. Sharing is caring, and synchronizing knowledge is an important factor for the teaching teams as well.

05 DISCUSSION

05 DISCUSSION

The goal of this thesis was to develop structured means to support the geographically distributed design process in educational environments by studying the most critical challenges student teams face during their projects. The in-depth interviews with ME310 alumni revealed several challenges, such as difficulties synchronizing knowledge, problems with team dynamics, and communication of concepts to reach a mutual understanding of knowledge. The findings were similar to the challenges discussed in the theory section. After analyzing the research data, the focus was set on assisting distributed teams in the convergence process; to enable teams to reach a mutual understanding of the knowledge created as well as to understand others' points-of-view to make effective decisions as a team. As noted in the analysis, the teams had several problems due to insufficient communication of concepts, which led to misconceptions and problems with reaching consensus. So far, there has been little research done in this area especially in the field of design (Yang 2010). The question why decision-making in distributed teams is challenging has received some attention by scholars, but studies on how to improve it have been almost non-existent. Therefore, I'm hoping that this study will provide a better understanding of the how as well as the process that might help teams to reach consensus with the help of supportive means that have been designed specifically for this purpose.

In the study conducted by Du et al. (2012), the importance of communicating design intents to reach a higher level of understanding was emphasized as a critical activity. A shared understanding is possibly the most important factor influencing effective teamwork, especially in distributed settings, since it affects all phases of the project. As discussed in theory section, it also has significant impacts on the teams' ability to collaborate together (Hinds & Weisband 2003). As noted in this study, decision-making is often the phase in which the teams struggle the most and the lack of shared

understanding has direct effects on this. It is also the phase in which the problem of not having a common understanding becomes most evident. Inspired by the study by Du et al. (2012) as well as finding similar insights from my own research data, synchronizing different knowledge basis as well as communicating the rationale for design decisions ended up being the most significant factor guiding the concept development phase.

In the end, the Convergence Guide came to life in order to fulfill four main objectives: 1) To enable teams to agree on common values and criteria 2) To understand others' points-of-view, 3) To reach a mutual understanding of the knowledge and concepts created, and 4) To make decisions as a team based on learnings and teams' own value criteria. From my point-of-view, these objectives give out clear reasoning for each step and exercise that are presented in the guide. Furthermore, the solution truly aims to answer to the critical problems presented in the theoretical background as well as in the findings of my research. In hindsight, although testing with real users has validated the preliminary potential for the guide, the virtual context is not as emphasized in the prototype as I would have hoped for. Hinds & Bailey (2003) explain that distributed teams might struggle with finding a mutual understanding, a shared context, as a result of distance. Although I kept this statement in mind throughout the process, the aim in this study was to not to produce a ready-made product, but a concept-level solution that demonstrates the potential of the idea. The fact that the concept was tested with real target users, and it received encouraging feedback as well as proof that it can be effective, holds a great promise regarding next steps. More use cases as well as developing a version that would function in virtual environments would be needed to develop the idea further. Nonetheless, I am eagerly waiting to see how the solution continues to evolve after this thesis.

Reflecting on the process

When considering the different phases of this thesis project I realized that converging was a challenge, not only for the students but for me as well, even though I was not working in a team full of diversity but mostly on my own. However, as I came to understand that I was following the same divergence and convergence path as the student teams it felt like a funny coincidence that also provided a good structure for my work. The research phase of this project started from an ambitious setup: What are the most critical challenges global virtual teams face during their projects in the context of the ME310-course, and also, what are the reasons causing these challenges. Acknowl-

edging the fact that this question is extremely broad and could have resulted in various possible ways, I saw it as the only way to start the project. Nevertheless, answering this question with was not an easy task. The reason behind this is that the amount of challenges proved to be enormous. Regardless of that, from my point-of-view, it was necessary to understand the whole context before starting to develop any solutions. Also, as noted, a few of the discovered challenges were more critical than others. It can be said that the overall umbrella above the most critical problems is the lack of mutual understanding - a shared context regarding people, backgrounds, skills as well as the knowledge that the team produces during the journey. This problem is as evident in the early phases of the project as in the end. Moreover, the challenge is continuous throughout the project and cannot be completely solved by designing a simple method or tool. From my point-of-view, the choice of focusing on a specific phase, converging, was a good decision.

> *How can the globally distributed collaborative design process be supported with the development of structured means?*

The third, and possibly the most important, research question mentioned above was a difficult nut to crack. In the beginning, the question was extremely open and broad as the goal was to let the process and the discovered needs guide the development. As in the student projects researched in this study, this thesis project was also full of ambiguity. During the project, I doubted my skills and myself as the discovered problems seemed to be too challenging to be solved alone. At this point especially, I started missing the diversity that multidisciplinary projects have to offer. Not being able to share thoughts with anyone, who would be as immersed in the topic as I was, resulted in skepticism regarding the outcome. However, reflecting on the final outcome, I can sincerely say that I am satisfied with it. Moreover, during the last weeks of this project I have received great support from other teaching assistant and colleagues. The fact that other peers see potential in this solution gives me the feeling of doing something valuable.

Most importantly, this journey has been highly educating: I have been able to deeply understand the problems the student teams face and therefore, to offer guidance and support. I have personally learned and realized the importance of effective facilitation whether it is through structured methods and tools or personal contact. During the project I also noticed that our education does not necessarily provide enough means for this type of design work or for developing methods such as the Convergence Guide. Having said that I realize that learning new skills might be required during the process.

Although inspiration and methods can be found from design games and service design, at times I felt like I was lost and did not know how to move forward. After completing the whole process, I cannot for sure say what would I do differently, except that I would love to work in a team full of diversity. To conclude, I can honestly say that I have a feeling I have produced something that can actually be useful and at the same time, answer to a real problem. This is the most important driver for me as a designer. The challenge of making effective decisions in a multidisciplinary team while working remotely is an important issue, which should be addressed as the role of technology in collaboration evolves.

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APPENDIX

1. List of interview qustions

2. Anonymous list of interviewees and their field of study

3. Convergence Guide

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1. List of interview qustions

WARM-UP & BACKGROUND INFORMATION

- Name & background?
- Project brief (project type)?
- Other team members and their backgrounds?
- Time difference?
- Can you shortly describe the final outcome of the project?
- Going through the course process as a reminder (with a process map image). With the help of this time line can you shortly describe what were the biggest turning points in your project?

COMMUNICATION TOOLS & METHODS:

- Which communication/sharing tools your team used during the year and for what purpose?
- What kind of information did you share and why?
- Which ones of these communication tools proved to be successful/useful for your team? Why? Which not?
- Did you change any of the tools used or add new ones during the project? What was the reason behind that?
- What kind of tool would have been useful for your team?

TEAM MEETINGS

- How much time did you use for weekly communication with your global team? (including all tools) Was that sufficient?

- How often did you have team meetings with your global partners?
- What was usually the purpose of those meetings?
- Were there times when you met more often? Global communication increased significantly? Why?
- Did the team use any special equipment or tools for enhancing the communication in virtual meetings? (e.g. physical objects, hand gestures, signs, visuals..). How did you use those?
- Which methods proved to be successful? Which not?

DIFFERENT PHASES OF THE PROJECT & METHODS

- If you think about the different phases of the project (ideation, brainstorming, prototyping, user testing, decision making etc..).. what was the most difficult phase for your team? Why?
- Did you change the ways of collaboration/working for different phases of the project?
- What kind of changes did you make? What was the impact?
- Did you try doing "virtual brainstorming" with your global team members? How did it go?
- How did you communicate ideas & concepts to the other half of the team?
- ...What about prototyping?
- Were you able to prototype together remotely? Can you give an example?
- ...What about user testing?
- Were you able to communicate the results of the user testing effectively?
- How did you make decisions? Did you use any special tools/methods for that?
- How was the workload divided for the final phase of the project (when building the final solution)? How would you describe your remote collaboration in that phase? Were you able to collaborate efficiently?

TEAM CULTURE:

- Did you have a specific place your team liked to use for virtual/global communication (team meetings)? Why?
- How would you describe the atmosphere in your global discussions? (e.g. formal or informal?)
- Can you describe the team dynamics throughout the year? What affected the dynamics the most?
- Do you think the workload was divided equally amongst the two teams? If not, why?

- Did the team members have specific roles? What was your role?
- How would you describe the global collaboration throughout the year?

PROBLEMS / CHALLENGES:

- Did you experience communication problems during the year?
- How did you solve those problems? Did it work?
- Do you feel like you were always updated about your global teams' progress? (and vice versa)
- What was the most challenging task/phase in your project? (remote collaboration?)
- What were the teams' strengths in global collaboration?
- ... What about weaknesses?

CONCLUSION

- If you would go through the process again what would you change in the remote collaboration?
- Can you think of moments when your teams' remote collaboration excelled?

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2. Anonymous list of interviewees and their field of study

A	Female	Designer	Aalto
B	Male	Mechanical Engineer	Aalto
C	Female	Business	Aalto
D	Male	Mechanical Engineer	Aalto
E	Male	Mechanical Engineer	Aalto
F	Male	Mechanical Engineer	Aalto
G	Male	Software Engineer	Aalto
H	Female	Designer	Aalto
I	Male	Designer	Aalto
J	Female	Mechanical Engineer	Aalto
K	Male	Designer	Aalto
L	Male	Software Engineer	Hasso Plattner Insitute
M	Male	Software Engineer	Hasso Plattner Institued
N	Male	Designer,	Swinburne University
O	Female	Mechanical Engineer	Ecole-de Paris
P	Male	Business	Saint-Gallen

CONVERGENCE GUIDE

Developed to support decision-making in
distributed design projects

Prepare → Define → Synthesize → Evaluate → Decide

WHY THIS GUIDE CAME TO LIFE?

MARIA SOLOVJEW
Industrial Designer

Aalto University
School of Arts, Design, and Architecure
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The Convergence Guide is a major part of the outcome developed for my Master's thesis in Aalto University, School of Arts, Design, and Architecture, 2015. After partipating in several distributed product development projects, team members varying from disciplines, cultures, and backgrounds, I had a strong desire to to address the challenges emerged in distributed collaboration.

In the beginning of my research project, my aim was to discover the biggest challenges global virtual team face during their projects. The outcome was broader than I expected as the results showed teams experiencing several challenges, such as difficulties synchronizing knowledge, missunderstandings, or problems with team coordination. However, one of the challenges stood out - converging and making decisions as a team. So far, decision making in the teams that I have worked in, has never been easy. In fact, it has been more than challenging. Different point-of-views, misconceptions, and lack of understanding cause problems and even severe conflicts. Therefore, with the help of this guide, my goal is to provide structure to this process by using carefully designed methods and worksheets as well providing a clear rationale for each step. All the material presented in this guide is based on the reseach I have done for my Master's thesis. Naturally, my personal experiences have had a significant impact on the outcome as well.

The methods used in this guide have been validated by testing with students, although the work is still in progress and more feedback from real use cases is required to develop the Guide further. Based on my research and personal experiences of team work, my hypothesis is: By creating a common understanding of knowledge and people, as well as formulating a commong ground on which basis the decisions are made, it will be easier to reach consensus as a team. I hope you enjoy using this guide!

1/3 INSTRUCTIONS

This guide offers a step-by-step guideline on how to communicate and evaluate ideas to help you reach effective decisions as a team.

WHY A DECISION MAKING GUIDE?

Making decisions in a team is often time-consuming and challenging. However, teams can often make far better decisions than any person on his or her own because there are more capabilities to explore the situation from different points-of-view, provide input, discuss, debate and make the best final choice. In order to make efficient decisions with your team, it is important to be prepared and use structured methods to guide the process. This toolkit offers a step-by-step guideline on how to communicate and evaluate ideas to help you reach effective decisions as a team.

MAIN OBJECTIVES

The main goal of this guide is to enable your team to:

1) agree on common values and criteria

2) understand others' points-of-view

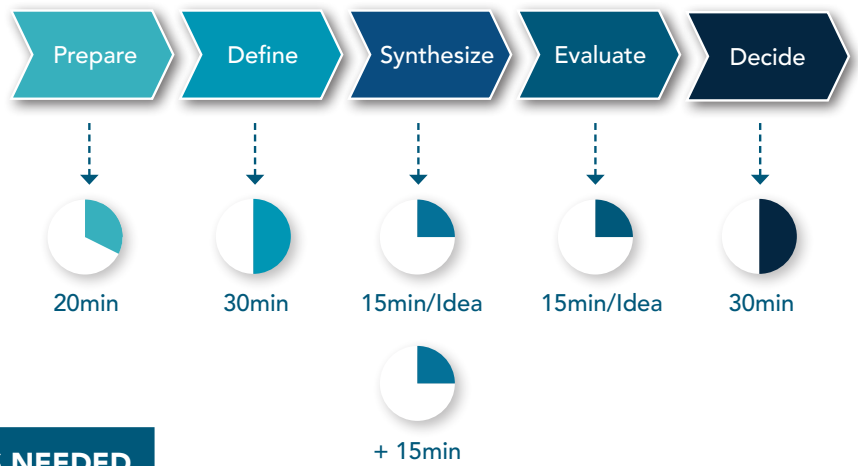
3) reach a mutual understanding of the knowledge and concepts created

4) make decisions as a team based on learnings and teams' own value criteria

INSTRUCTIONS

STRUCTURE

Before making decisions as a team it is essential to agree on the basis on which decisions are made, and to share sufficient information on the possible alternatives in order to reach a mutual understanding of the potential solutions. This guide includes worksheets and a process description for each step, which enables your team to reach that target.



WHAT IS NEEDED

1. *Have prototypes prepared and tested (see next page for important tips)*
2. *Make sure your whole team participates in the convergence session*
3. *Prepare in advance to save time in the decision making process; print out the instructions and sufficient amount of worksheets, have post-its, pens, extra paper, and snacks/ refreshments to refuel while working.*
4. *Choose an objective facilitator to guide the process*
5. *Follow the given instructions and time recommendations*

"What I cannot build, I cannot understand"

– Richard Feynman

To be able to go through the convergence process, your team needs to have materialised the ideas as prototypes and tested them. What matters is how the ideas are prototyped and tested and how the data obtained from testing is communicated in the decision making situation. In order to evaluate ideas objectively, remember to keep these in mind when developing potential solutions.

PROTOTYPING TIPS

a) Define!

A great idea solves a real problem or/and a user need. Define a specific user and the discovered problem you are seeking asnwers for. A good solution has a clear design rationale.

b) Build it!

In order to communicate your idea effectively it needs to be demonstrated. A picture is not enough to convey the message to the other side of the world - make it tangible!

c) Test it!

To discover the potential and to validate assumptions, the idea needs to be tested with real users. Think before your test - what is it that you want to find out?

d) Document!

A 30 second video works better than a picture!

20min

TUNE IN

WHY

It is extremely important to understand what others value or believe to be important when making decisions. The first step in doing this is to understand the teams' status regarding the process and what are the personal goals regarding the outcome. Start with an activity where everyone can participate in a meaningful way: share your personal values and passions.

HOW

1. *Use five minutes to write down three most prominent values you have (using post-its) regarding a successfull outcome. What do you consider being important when evaluating ideas and making decisions? What are you passionate about in a project? What makes projects successful?*

2. *Share your passions and values with your team. Collect the post-its and read all of them aloud. Discuss. Can you find similarities? Passions that complement each other?*

Member: *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*
Member: *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*
Member: *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*	*Member:* *a)* *b)* *c)*

Next step: Define

30min

DEFINE

INSTRUCTIONS

WHY

After sharing your personal passions, it must be agreed on which basis the decisions are made. Mutually agreed objective criteria help to evaluate ideas and to see the full potential of all the proposed solutions.

HOW - CRITERIA SHEET

1. As a team, discuss and agree on evaluation criteria. There are predefined criteria (below) that could be included in the evaluation process. Depending on the project, the predefined criteria might require fine-tuning.

1. *User experience - How well does the solution answer to a discovered problem or need?*
2. *Feedback - How positive or potential are the results of testing?*
3. *Feasibility - How well are you able to implement the solution?*
4. *Uniqueness - How novel is the concept? How big is the impact?*

2. Depending on the project context, additional criteria might be needed - Choose up to 4 from the list below or come up with your own set. Remember to have a look at the results of the tuning-in exercise

3.Agree on selected set of criteria as a team before moving into the next steps.

EXAMPLES OF ADDITIONAL CRITERIA

SCALABILITY	USABILITY	COSTS	COMPETITEVESS
BENEFITS	AESTHETICS	MAINTAINABILITY	UNIQUENESS
FLEXIBILITY	SIMPLICITY	MANUFACTURABILITY	MARKET POTENTIAL
POTENTIAL	SUSTAINABILITY	IMPLEMENTATION	INNOVATIVENESS

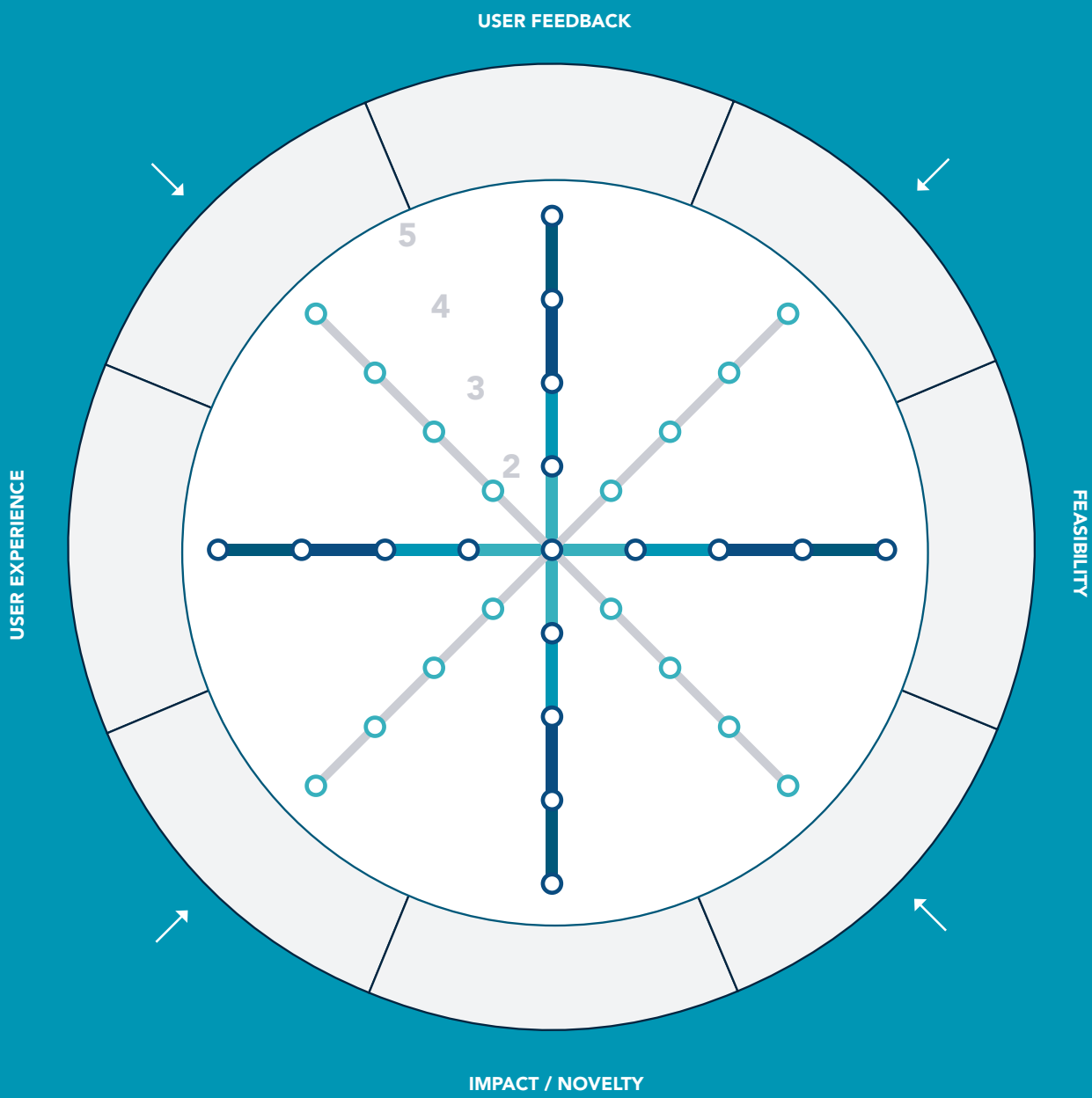
Next step: Use the CRITERIA SHEET

30min

CRITERIA SHEET

DECIDE VALUES AND CRITERIA

1. *As a team, agree on criteria and place them on the image. Use maximum of eight attributes.*



Next step: Synthesize

15min/Idea

SYNTHESIZE

INSTRUCTIONS

WHY

After generating concepts and testing them, all relevant information needs to be gathered and shared with the whole team. In order to communicate concepts effectively, they need to be well summarized and documented - it's all about making the concepts understandable for everyone!

HOW - CONCEPT TEMPLATE

1. Come up with a name for the concept

- A good name is descriptive, inspiring, and imaginative!

2. Demonstrate the idea - Show videos of the prototype and user testing

"A picture is worth 1000 words, a prototype is worth 10 000 slides" - Glen Shires.

3. Come up with a one sentence description

- The core of the concept needs to be understood quickly

4. Clarify the problem this concept aims to solve . Why is it a problem?

- Remember, it should be based on your research

5. Describe the target user and the discovered need this concepts fulfils

- Be as specific as you can

6. Summarize the top three insights of user testing

- What was positive? Negative? Surprising?

Note!

Depending on the amount of concepts, it might be valuable to organize and categorize the concepts based on similarities...

Next step: Use the CONCEPT TEMPLATE

15min/Idea

CONCEPT TEMPLATE

MAKE THE CONCEPT UNDERSTANDABLE

1. *Name of the concept*

2. *Demonstrate the idea - Show don't tell*

3. *Describe the concept in one sentence*

4. *What is the problem this concept aims to solve? Why is that a problem?*

5. *Who is the target user? What is the discovered user need?*

6. *What are the top 3 key insights of user testing?*

1.

2.

3.

Next step: Vision Statement

15min

SYNTHESIZE

GO BEYOND

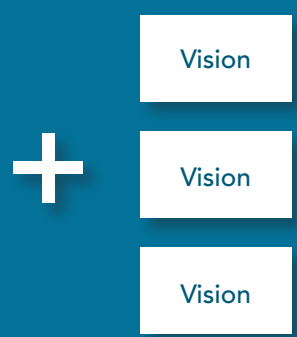
WHY

Before evaluating the ideas, it is important to understand the full potential and look at each concept from different perspectives.

HOW

1. Have a look at the personal values created in the beginning and reflect them with each top concept. How can you make each concept better with the help of your team member's passions? Individually, write down a short, positive, vision statement for each concept: How will this concept change the world? Why should we choose this? How can we unleash the full potential?

2. Read your vision statements aloud, place them next to the concept templates, and discuss on the possibilities.



Next step: Evaluate

15min/Idea

EVALUATE

INSTRUCTIONS

WHY

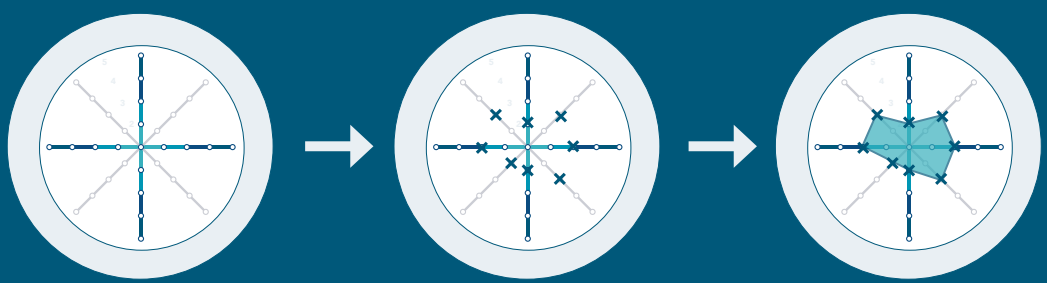
Next step is to evaluate concepts. Drawing each concept's performance in the predefined criteria helps you to see differences visually and compare them.

HOW - EVALUATION SHEET

1. Evaluate each concept based on chosen criteria on a scale 0-5, then connect the dots. In general, the better the score - the larger the area - the better the evaluation. Try to be as objective as you can: evaluate ideas purely based on merits and learnings.

Idea A

Idea B



Next step: Use the EVALUATION SHEET

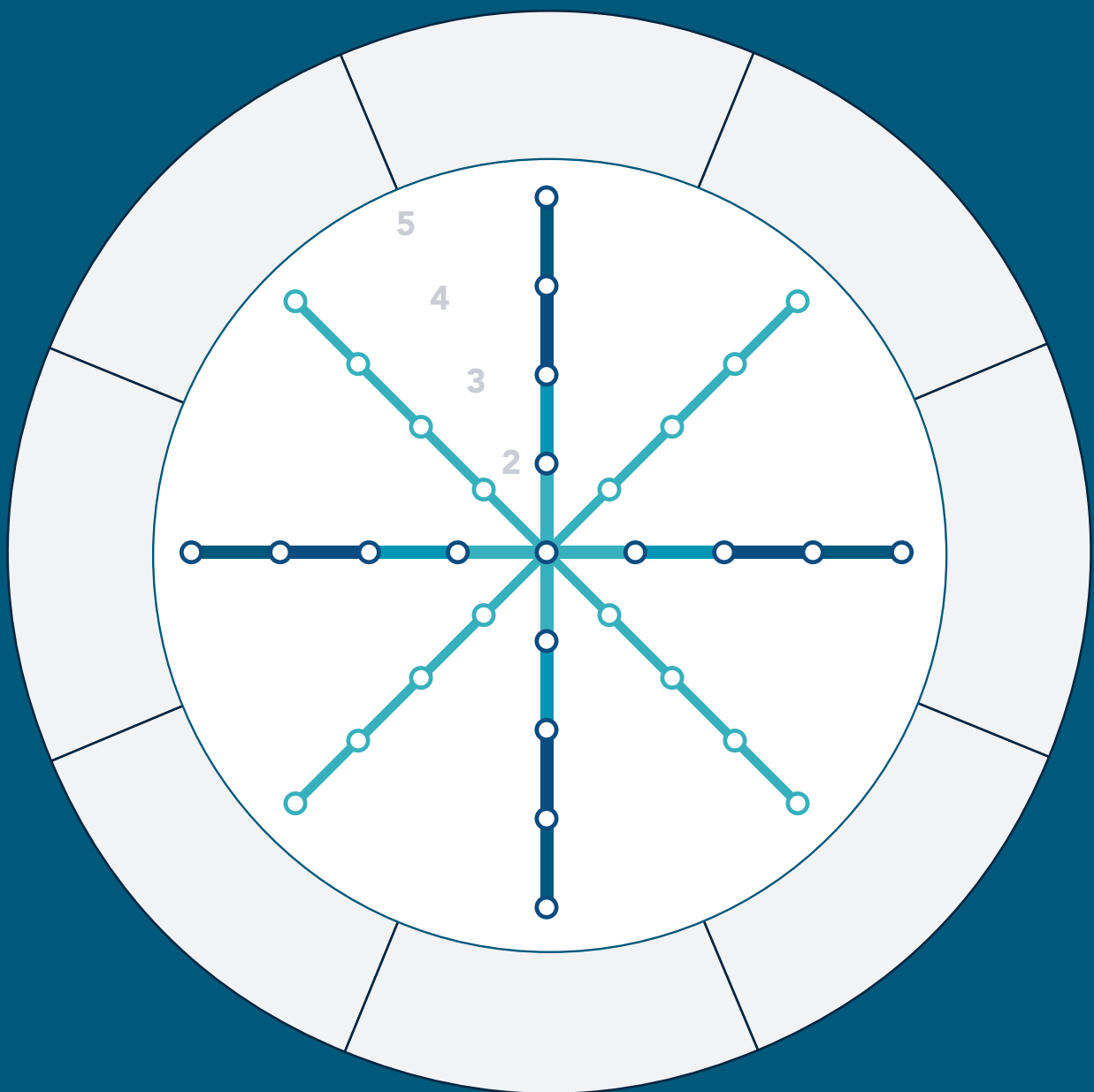
15min/Idea

EVALUATION SHEET

EVALUATE THE IDEA

1. *Name of the concept*

2. *Evaluate each idea based on mutually agreed criteria*



Next step: Decide

30+ min

DECIDE

INSTRUCTIONS

WHY

Last step in making your decision is to reach consensus as a team. A good decision is based on solid learnings and a clear rationale. There also needs to be passion and motivation towards the chosen solution. In this discussion process, each team member has to have the opportunity to provide input and opinions. But beware of compromise - it might seem like an easy option, but it also might jeopardise the quality of the final outcome. All members should discuss alternatives until they agree on a solution. Use well constructed, objective arguments based on shared information. Build on other people's points-of-view. Use discussion to make rather than avoid decisions.

HOW

1. Compare the visual criteria evaluations. Which ideas have the most promising scores?
Are there similar ideas? Combine if necessary, but do not force it.
Choose maximum top 3 concepts.

4. Discuss and agree on the most viable option in terms of evaluation scores,
passions and your vision.

5. Reflect on the decision made. Are you happy with the result as a team?

6. Take your vision for the chosen concept and make an action plan how to make it real!
Come up with a strong vision as a team.

CONGRATULATE YOURSELF!